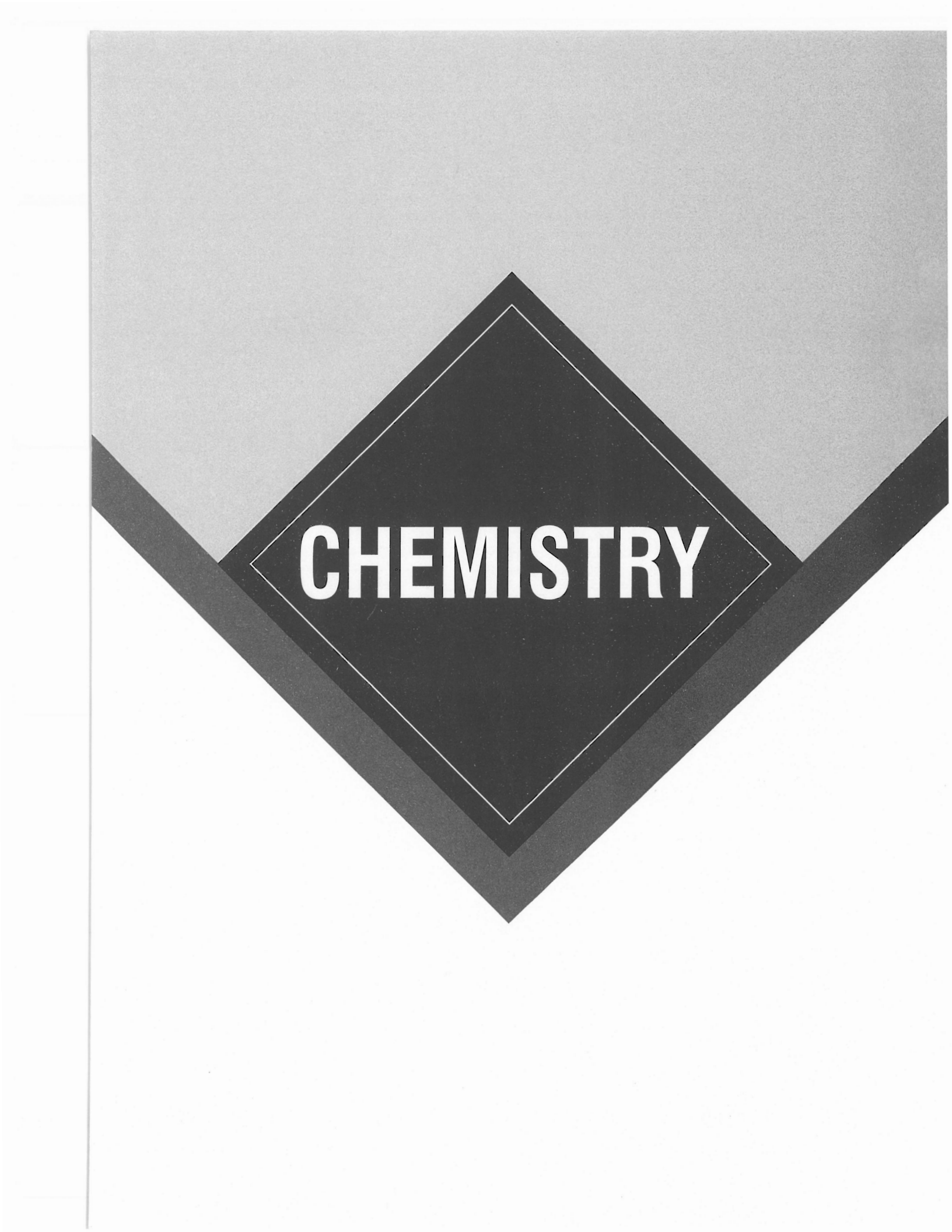




CHEMISTRY

Some Basic Concepts of Chemistry

- What is the mass of water formed when 1.6 g of methane gas is completely burnt in excess oxygen?
(a) 1.8 g (b) 2.4 g
(c) 3.2 g (d) 3.6 g
(e) 4.8 g (2024)
- An organic compound contains 37.5% C, 12.5% H and the rest oxygen. What is the empirical formula of the compound?
(a) CH_4O (b) $\text{C}_2\text{H}_3\text{O}$
(c) CH_3O_2 (d) $\text{C}_2\text{H}_4\text{O}$
(e) CH_3O (2024)
- How many grams of HCl will completely react with 17.4 g of pure $\text{MnO}_{2(s)}$ to liberate $\text{Cl}_{2(g)}$?
(Atomic mass Mn = 55.0; H = 1; Cl = 35.5)
(a) 14.6 g (b) 7.3 g
(c) 21.9 g (d) 29.2 g
(e) 34.8 g (2024)
- 14 g of cyclopropane burnt completely in excess oxygen. The number of moles of water formed is
(a) 1.4 moles (b) 2.8 moles
(c) 2.0 moles (d) 1.0 mole
(e) 4 moles (2024)
- 10 g of alcohol is dissolved in 90 g of water. The percentage of alcohol in the solution is
(a) 10% (b) 90% (c) 20% (d) 100%
(e) 1% (2024)
- The mass percentage of glucose in acetonitrile when 6 g of glucose is dissolved in 294 g of acetonitrile is
(a) 6% (b) 10% (c) 8% (d) 4%
(e) 2% (2024)
- The number of electrons in one mole of methane
(a) 6.023×10^{23} (b) 60.23×10^{23}
(c) 0.6023×10^{23} (d) 602.3×10^{23}
(e) 6023×10^{23} (2023)
- Which one of the following contains the highest number of oxygen atoms?
(a) One mole of aluminium sulphate
(b) Two moles of ferrous sulphate
(c) Three moles of hydrogen peroxide
(d) Two moles of potassium permanganate
(e) One mole of potassium dichromate (2022)
- Among the following pairs of compounds, the one that does not illustrate the law of multiple proportions, is
(a) NO and NO_2 (b) CuO and Cu_2O
(c) FeO and Fe_2O_3 (d) H_2O and H_2S
(e) NO and N_2O (2022)
- The chemistry teacher asked the students to prepare 20% w/w solution of urea [NH_2CONH_2] in water. Which one of the following solution does not confirm to the required composition?
(a) 6 g urea dissolved in 24 g water
(b) 20 g urea dissolved in 80 g water
(c) 10 g urea dissolved in 40 g water
(d) 4 g urea dissolved in 16 g water
(e) 15 g urea dissolved in 30 g water (2022)
- The elemental analysis of an organic compound gave C : 38.71%, H : 9.67%. What is the empirical formula of the compound?
(a) CH_2O (b) CH_3O
(c) CH_4O (d) CHO
(e) CH_5O (2022)
- A cooking gas contains carbon and hydrogen only. A volume of 11.2 L of this gas is found to weigh 22 g at STP. Then the molecular formula of the gas is
(a) C_3H_8 (b) C_2H_2
(c) C_2H_4 (d) C_2H_6
(e) C_3H_4 (2021)
- Which one of the following will have the largest number of atoms?
(a) 1 g $\text{Au}_{(s)}$ (b) 1 g $\text{Na}_{(s)}$
(c) 1 g $\text{Li}_{(s)}$ (d) 1 g of $\text{Cl}_{2(g)}$
(e) 1 g of $\text{O}_{2(g)}$ (2020)
- An organic compound contains 24% carbon, 4% hydrogen and remaining chlorine. Its empirical formula is
(a) CHCl (b) CH_2Cl
(c) CHCl_2 (d) CH_3Cl
(e) CH_2Cl_2 (2020)
- On passing silent electric discharge through oxygen in an ozoniser, 5.5 mol % of oxygen is converted to ozone. How many moles of O_2 and O_3 result when 35 moles of O_2 is initially present?

- (a) 33.0 (b) 34.4
(c) 35.0 (d) 31.8
(e) 31.0 (2019)
16. A solution of methanol in water is 20% by volume. If the solution and pure methanol have densities of 0.964 kg L^{-1} and 0.793 kg L^{-1} , respectively, find the per cent of methanol by weight.
(a) 15.8 (b) 16.45
(c) 20 (d) 14.8
(e) 17.6 (2019)
17. Mass % of carbon in ethanol is
(a) 52 (b) 13 (c) 34 (d) 90
(e) 80 (2018)
18. The molality of the 3 M solution of methanol if the density of the solution is 0.9 g cm^{-3} is
(a) 3.73 (b) 3.0 (c) 3.33 (d) 3.1
(e) 3.2 (2017)
19. 10 g of MgCO_3 decomposes on heating to 0.1 mole CO_2 and 4 g MgO . The per cent purity of MgCO_3 is
(a) 24% (b) 44% (c) 54% (d) 74%
(e) 84% (2017)
20. The compound $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ has 50% H_2O by mass. The value of 'x' is
(a) 4 (b) 5 (c) 6 (d) 7
(e) 8 (2017)
21. If 27 g of water is formed during complete combustion of pure propene (C_3H_6), the mass of propene burnt is
(a) 42 g (b) 21 g (c) 14 g (d) 56 g
(e) 40 g (2016)
22. When 2.46 g of a hydrated salt ($\text{MSO}_4 \cdot x\text{H}_2\text{O}$) is completely dehydrated, 1.20 g of anhydrous salt is obtained. If the molecular weight of anhydrous salt is 120 g mol^{-1} . What is the value of x?
(a) 2 (b) 4 (c) 5 (d) 6
(e) 7 (2016)
23. An organic compound contains 90% carbon and 10% hydrogen by mass. Its empirical formula is
(a) C_2H_4 (b) C_3H_6 (c) C_3H_8 (d) C_3H_4
(e) C_2H_6 (2015)

Answer Keys

1. (d) 2. (a) 3. (d) 4. (d) 5. (a) 6. (e) 7. (b) 8. (a) 9. (d) 10. (e)
11. (b) 12. (a) 13. (c) 14. (b) 15. (b) 16. (b) 17. (a) 18. (a) 19. (e) 20. (c)
21. (b) 22. (e) 23. (d)

Hints & Explanations

1. (d): $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
 $\begin{array}{ccccccc} 16 \text{ g} & 2 \times 16 = 32 \text{ g} & 44 \text{ g} & 2 \times 18 = 36 \text{ g} \end{array}$
 1 mol (16 g) of methane on combustion gives 2 mol (36 g) of water.

$\therefore$ 1.6 g of methane will give $\frac{36}{16} \times 1.6 = 3.6 \text{ g}$ of water

2. (a):

	C	H	O
Percentage composition	37.5	12.5	50
Number of moles	$\frac{37.5}{12} = 3.125$	$\frac{12.5}{1} = 12.5$	$\frac{50}{16} = 3.125$
Simplest ratio	$\frac{3.125}{3.125} = 1$	$\frac{12.5}{3.125} = 4$	$\frac{3.125}{3.125} = 1$

Hence, empirical formula is CH_4O .

3. (d): $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$
 $\begin{array}{ccc} 55+32 & 4(35.5+1) & \\ = 87 \text{ g} & = 146 \text{ g} & \end{array}$

For 87 g MnO_2 , amount of HCl required = 146 g

$\therefore$ For 17.4 g MnO_2 , amount of HCl required

$$= \frac{146 \times 17.4}{87} = 29.2 \text{ g}$$

4. (d): $\text{C}_3\text{H}_6 + \frac{9}{2}\text{O}_2(\text{Excess}) \longrightarrow 3\text{CO}_2 + 3\text{H}_2\text{O}$
 $\begin{array}{ccc} 12 \times 3 + 1 \times 6 & & 3(2 \times 1 + 16) \\ = 42 \text{ g} & & = 54 \text{ g} \end{array}$

42 g cyclopropane reacts with excess of oxygen to form 54 g H_2O .

$\therefore$ 14 g cyclopropane reacts with excess of oxygen to form $\frac{54 \times 14}{42} = 18 \text{ g H}_2\text{O} = 1 \text{ mol H}_2\text{O}$

5. (a): Given mass of alcohol = 10 g

Mass of water = 90 g

Total mass of solution = 90 + 10 = 100

Mass % of alcohol = $\frac{10}{100} \times 100 = 10\%$

6. (e): Mass% of glucose

$$= \frac{\text{Mass of glucose}}{\text{Mass of glucose} + \text{Mass of acetonitrile}} \times 100$$

$$= \frac{6}{6 + 294} \times 100 = \frac{6}{300} \times 100 = 2\%$$

7. (b): No. of molecules in one mole of methane = N_A

No. of electrons in one molecule of methane = 10

$\therefore$ No. of electrons in one mole of methane = $N_A \times 10$
 $= 6.023 \times 10^{23} \times 10 = 6.023 \times 10^{24} = 60.23 \times 10^{23}$

8. (a) : 1 mol of aluminium sulphate $\text{Al}_2(\text{SO}_4)_3$ has 12 moles of oxygen atoms.

Number of oxygen atoms = $12 \times N_A$

1 mole of ferrous sulphate FeSO_4 contains 4 moles of oxygen atoms.

2 moles will have 8 moles of oxygen atoms.

Number of oxygen atoms = $8N_A$

3 moles of H_2O_2 has 6 moles of oxygen atoms.

Number of oxygen atoms = $6N_A$

2 moles of potassium permanganate (KMnO_4) has 8 moles of oxygen atoms.

Number of oxygen atoms = $8N_A$

1 mole of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) has 7 moles of oxygen atoms.

Number of oxygen atoms = $7N_A$

9. (d) : Law of multiple proportion states that if two elements form more than one compound, then the ratios of the masses of the second element which combine with a fixed mass of the first element will always be ratios of small whole numbers.

H_2O and H_2S cannot illustrate this law as they have different elements such as oxygen and sulphur.

10. (e) : In (a), 6 g urea dissolved in 30 g water

$$\text{Mass percentage} = \frac{6}{30} \times 100 = 20\%$$

$$\text{In (b), 20 g urea in 100 g water} \Rightarrow \frac{20}{100} \times 100 = 20\%$$

$$\text{In (c), 10 g urea in 50 g water} \Rightarrow \frac{10}{50} \times 100 = 20\%$$

In (d), 4 g urea dissolved in 20 g water

$$\Rightarrow \frac{4}{20} \times 100 = 20\%$$

In (e), 15 g urea dissolved in 45 g water

$$\Rightarrow \frac{15}{45} \times 100 = 33.3\%$$

11. (b) :

	C	H	O
Percentage of element	38.71	9.67	$100 - (38.71 + 9.67) = 51.62$
Number of moles	$\frac{38.71}{12} = 3.22$	$\frac{9.67}{1} = 9.67$	$\frac{51.62}{16} = 3.22$
Simplest ratio	$\frac{3.22}{3.22} = 1$	$\frac{9.67}{3.22} = 3$	$\frac{3.22}{3.22} = 1$
Hence, empirical formula = CH_3O			

12. (a) : 11.2 L gas at STP weigh = 22 g

22.4 L gas at STP weigh = 22×2 g (Molecular mass)

Hence, the gas which weigh equal to 44 g is C_3H_8 .

13. (c) : (a) 1 g Au(gold) (molar mass = 197 g/mol) :

Number of moles = $1/197 = 0.005$

Number of atoms = $0.005 N_A$

($N_A = 6.02 \times 10^{23}$, Avogadro number)

(b) 1 g Na (molar mass = 23 g/mol) :

$$\text{Number of moles} = \frac{1}{23} = 0.04$$

Number of atoms = $0.04 N_A$

(c) 1 g Li (molar mass = 7 g/mol) :

$$\text{Number of moles} = \frac{1}{7} = 0.143$$

Number of atoms = $0.143 N_A$

(d) 1 g of Cl_2 (molar mass = 71 g/mol) :

$$\text{Number of moles} = \frac{1}{71} = 0.0140$$

Number of atoms = $0.0140 \times 2 N_A = 0.028 N_A$

(e) 1 g of O_2 (molar mass = 32 g/mol) :

$$\text{Number of moles} = \frac{1}{32} = 0.03$$

Number of atoms = $0.03 \times 2 N_A = 0.06 N_A$

Therefore, 1 g $\text{Li}_{(s)}$ has largest number of atoms.

14. (b) :

Element	Percentage	Atomic weight	Ratio	Simple ratio
H	4	1	4	2
C	24	12	2	1
Cl	72	35.5	2.03	1

Empirical formula = CH_2Cl

15. (b) : Moles of O_2 initially present = 35 moles

$$\text{Moles of } \text{O}_2 \text{ converted to } \text{O}_3 = \frac{35 \times 5.5}{100} = 1.925 \text{ moles}$$

Remaining $\text{O}_2 = 35 - 1.925 = 33.075$ moles

As $3\text{O}_2 \rightleftharpoons 2\text{O}_3$,

thus, 3 moles oxygen produces 2 moles of O_3

1.925 moles oxygen will produce = 1.283 moles of O_3

Total moles of O_2 and $\text{O}_3 = 33.075 + 1.283 = 34.358 \approx 34.4$

16. (b) : Volume of solution = 100 L

Then, volume of methanol = 20 L

Mass of solution = $V \times d = 100 \times 0.964 = 96.4$ kg

Mass of methanol = $20 \times 0.793 = 15.86$ kg

$$\text{Mass \% of methanol} = \frac{15.86}{96.4} \times 100 = 16.45\%$$

17. (a) : Ethanol is $\text{C}_2\text{H}_5\text{OH}$.

Molecular mass = $12 \times 2 + 6 \times 1 + 16 \times 1$

$$= 24 + 6 + 16 = 46$$

Mass of carbon in ethanol = $12 \times 2 = 24$

$$\begin{aligned} \text{Mass \% of carbon} &= \frac{\text{Mass of carbon}}{\text{Molar mass of compound}} \times 100 \\ &= \frac{24}{46} \times 100 = 52\% \end{aligned}$$

$$18. (a): m = \frac{M \times 1000}{(1000d - M \times M_B)}$$

where, M = Molarity

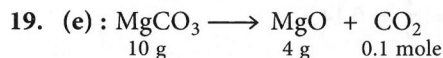
m = Molality, d = Density

M_B = Molal mass of solute

Molar mass of $\text{CH}_3\text{OH} = 12 + 4 \times 1 + 16 = 32 \text{ g mol}^{-1}$

Substituting values in equation, we get

$$m = \frac{3 \times 1000}{1000 \times 0.9 - 3 \times 32} = \frac{3000}{900 - 96} = 3.73 \text{ m}$$



10 g 4 g 0.1 mole

Molar mass of $\text{MgCO}_3 = 24 + 12 + 3 \times 16 = 84 \text{ g mol}^{-1}$

Molar mass of $\text{MgO} = 24 + 16 = 40 \text{ g mol}^{-1}$

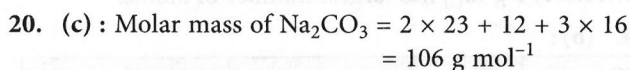
Molar mass of $\text{CO}_2 = 12 + 2 \times 16 = 44 \text{ g mol}^{-1}$

40 g of MgO is obtained from 84 g of MgCO_3

$\therefore$ 4 g of MgO will be obtained from

$$\frac{84}{40} \times 4 \text{ g of MgCO}_3 = 8.4 \text{ g of MgCO}_3$$

$$\% \text{ purity of MgCO}_3 = \frac{8.4}{10} \times 100 = 84\%$$



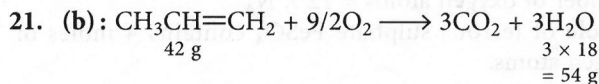
Molar mass of $\text{H}_2\text{O} = 2 \times 1 + 16 = 18 \text{ g mol}^{-1}$

Now, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ has 50% H_2O by mass.

$$\therefore \frac{50}{100} (106 + 18x) = 18x$$

$$53 + 9x = 18x$$

$$x = 5.888 \approx 6$$



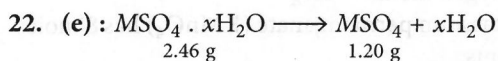
42 g

3×18

= 54 g

54 g of $\text{H}_2\text{O} \equiv 42 \text{ g}$ of propene burnt.

$$\therefore 27 \text{ g of H}_2\text{O} = \frac{42}{54} \times 27 = 21 \text{ g of propene burnt.}$$



2.46 g

1.20 g

Mass of water = $2.46 - 1.20 = 1.26 \text{ g}$

$$\therefore \text{No. of moles of H}_2\text{O} = \frac{1.26}{18} = 0.07$$

$$\text{No. of moles of MSO}_4 = \frac{1.20}{120} = 0.01$$

$\therefore$ 0.07 moles of water associated with 0.01 mole of salt. Thus, there are 7 moles of water per mole of anhydrous salt.

23. (d):

Element	%	Molar ratio	Simplest ratio	Simplest whole no. ratio
C	90	$\frac{90}{12} = 7.5$	$\frac{7.5}{7.5} = 1$	3
H	10	$\frac{10}{1} = 10$	$\frac{10}{7.5} = 1.33$	4

Thus, the empirical formula is C_3H_4 .



Structure of Atom

- The number of angular and radial nodes present in $4d$ orbitals are respectively
(a) 2, 1 (b) 4, 3 (c) 2, 2 (d) 3, 2
(e) 4, 2 (2024)
- The unit of an universal constant is cm^{-1} . What is the constant?
(a) Planck's constant (b) Boltzmann constant
(c) Rydberg constant (d) Avogadro constant
(e) Molar gas constant (2024)
- Which of the following set of quantum numbers is possible?
(a) $n = 3, l = 2, m_l = -4, m_s = 1/2$
(b) $n = 2, l = 2, m_l = 0, m_s = 1/2$
(c) $n = 2, l = 2, m_l = -1, m_s = 1$
(d) $n = 3, l = 2, m_l = -2, m_s = 1/2$
(e) $n = 3, l = 3, m_l = -2, m_s = 1/2$ (2024)
- The quantum number which determines the shape of the subshell is
(a) Principal quantum number
(b) Magnetic quantum number
(c) Azimuthal quantum number
(d) Spin quantum number
(e) Principal and magnetic quantum number. (2024)
- Which of the following statement is incorrect about Bohr's model of atom?
(a) It fails to account for the finer details of the hydrogen atom spectrum.
(b) Unable to explain the splitting of spectral lines in the presence of magnetic field.
(c) The angular momentum of electron is quantised.
(d) The ability of atoms to form molecule by chemical bonds.
(e) Unable to explain the splitting of spectral lines in the presence of electric field. (2024)
- Which of the following statement cannot be explained by the proposals of Dalton's atomic theory?
(a) Reorganisation of atoms in chemical reactions.
(b) Identical properties of all atoms of given element.
(c) The reason for combining of atoms.
(d) Formation of compounds from the combination of elements in a fixed ratio.
(e) Matter consists of individual atoms. (2023)
- A dinegative ion of the element X consists of 10 electrons and 8 neutrons. A dipositive ion of the element Y consists of 12 protons. The number of neutrons in Y is 1.5 times the number of neutron in atom X . Then the mass numbers of X and Y would be in the ratio
(a) 1 : 2 (b) 2 : 3 (c) 3 : 2 (d) 2 : 5
(e) 1 : 3 (2022)
- A particle of mass $6.6 \times 10^{-31} \text{ kg}$ is moving with a velocity of $1 \times 10^7 \text{ ms}^{-1}$. The de Broglie wavelength (in $\text{\AA}$) associated with the particle, is ($h = 6.6 \times 10^{-34} \text{ J s}$)
(a) 1 (b) 10 (c) 5 (d) 2
(e) 4 (2022)
- A fast moving particle of mass $6.63 \times 10^{-28} \text{ g}$ can be located with an accuracy of $1 \text{ \AA}$. The uncertainty in its velocity (in m s^{-1}) is about ($h = 6.63 \times 10^{-34} \text{ J s}$)
(a) 8×10^3 (b) 8×10^4
(c) 8×10^5 (d) 8×10^6
(e) 8×10^7 (2022)
- The number of electrons in an atom that may have the quantum numbers $n = 3$ and $m_s = +1/2$ is
(a) 32 (b) 9 (c) 18 (d) 16
(e) 8 (2021)
- The number of electrons, protons and neutrons in a species are equal to 10, 11 and 12 respectively. The proper symbol of the species is
(a) ${}^{22}_{11}\text{Na}^+$ (b) ${}^{23}_{11}\text{Na}$ (c) ${}^{23}_{10}\text{Ne}$ (d) ${}^{23}_{11}\text{Na}^+$
(e) ${}^{23}_{11}\text{Na}^{2+}$ (2020)
- Maximum number of photons emitted by a bulb capable of producing monochromatic light of wavelength 550 nm is _____, if 100 V and 1 A is supplied for one hour.
(a) 1×10^{24} (b) 5×10^{24}
(c) 1×10^{23} (d) 5×10^{23}
(e) 5×10^{22} (2019)
- Which of the following is the correct unit of angular momentum of an electron in an orbital of an atom?
(a) J s (b) J/s
(c) W/s^2 (d) W s
(e) J s^2 (2019)

14. Gd(64) has _____ unpaired electrons with sum of spin _____
 (a) 7, 3.5 (b) 8, 3 (c) 6, 3 (d) 8, 4
 (e) 9, 3.5 (2018)
15. The effective nuclear charge of an element with three valence electrons is 2.60. What is the atomic number of the element?
 (a) 1 (b) 2 (c) 3 (d) 4
 (e) 5 (2018)
16. Uncertainty principle is valid for
 (a) proton
 (b) methane
 (c) both (a) and (b)
 (d) 1 μm sized platinum particles
 (e) 1 μm sized NaCl particles. (2017)
17. The energy of an electron in the 3s orbital (excited state) of H-atom is
 (a) -1.5 eV (b) -13.6 eV
 (c) -3.4 eV (d) -4.53 eV
 (e) 4.53 eV (2017)
18. In the hydrogen atomic spectrum, the emission of the least energetic photon takes place during the transition from $n = 6$ energy level to $n = \dots\dots\dots$ energy level.
 (a) 1 (b) 3 (c) 5 (d) 4
 (e) 2 (2016)
19. The threshold frequency of a metal corresponds to the wavelength of x nm. In two separate experiments 'A' and 'B', incident radiations of wavelength $\frac{1}{2}x$ nm and $\frac{1}{4}x$ nm respectively are used. The ratio of kinetic energies of the released electrons in experiment 'B' to that in experiment 'A' is
 (a) $\frac{1}{3}$ (b) 2
 (c) 4 (d) 3
 (e) $\frac{1}{2}$ (2015)
20. The minimum values of uncertainties involved in the determination of both the position and velocity of a particle are respectively 1×10^{-10} m and 1×10^{-10} m s $^{-1}$. Then, the mass (in kg) of the particle is
 (a) 5.270×10^{-15} (b) 5.270×10^{-20}
 (c) 5.270×10^{-16} (d) 5.270×10^{-10}
 (e) 5.270×10^{-14} (2015)
21. The number of electrons with azimuthal quantum number $l = 1$ and $l = 2$ for Cr in ground state are respectively
 (a) 16, 5 (b) 16, 4 (c) 12, 4 (d) 16, 3
 (e) 12, 5 (2015)

Answer Keys

1. (a) 2. (c) 3. (d) 4. (c) 5. (d) 6. (c) 7. (b) 8. (a) 9. (c) 10. (b)
 11. (d) 12. (a) 13. (a) 14. (d) 15. (e) 16. (c) 17. (a) 18. (c) 19. (d) 20. (a)
 21. (e)

Hints & Explanations

1. (a) : For 4d orbital, $n = 4$ and $l = 2$
 Angular nodes = $l = 2$
 Radial nodes = $n - l - 1 = 4 - 2 - 1 = 1$
2. (c) : Rydberg constant for hydrogen has a value equal to $109,677 \text{ cm}^{-1}$.
3. (d) : When $n = 3$
 Possible values
 $l = 0$ to $n - 1 \Rightarrow 0, 1$
 $m_l = -2, -1, 0, +1, +2$
 $m_s = +\frac{1}{2}$ or $-\frac{1}{2}$
 Correct option $n = 3; l = 2; m_l = -2; m_s = +1/2$
4. (c) : Azimuthal quantum number 'l' determine the shape of the orbital and orbital angular momentum.
5. (d) : Bohr's model of atom failed to explain the ability of atoms to form molecules by chemical bonds.
6. (c) : Dalton's atomic theory could not explain the reason for combining of the atoms.
7. (b) : Given : X^{2-} contains 10 electrons.
 Y^{2+} contains 12 protons
 Neutrons in $Y = 1.5 \times$ neutrons in X .
 X contain 8 electrons, 8 protons and as given it contains 8 neutrons.
 Mass number of $X = 8 + 8 = 16$
 Neutrons in $Y = 1.5 \times 8 = 12$
 Mass number of $Y = 12 + 12 = 24$
 $\frac{\text{Mass number of } X}{\text{Mass number of } Y} = \frac{16}{24} = \frac{2}{3}$
8. (a) : Mass of particle = $6.6 \times 10^{-31} \text{ kg}$
 Velocity = $1 \times 10^7 \text{ m/s}$
 de Broglie wavelength, $\lambda = \frac{h}{mv}$
 $= \frac{6.6 \times 10^{-34}}{6.6 \times 10^{-31} \times 1 \times 10^7} = 1 \times 10^{-10} \text{ m} = 1 \text{ \AA}$

9. (c) : $m = 6.63 \times 10^{-28} \text{ g} = 6.63 \times 10^{-31} \text{ kg}$
 $\Delta x = 1 \times 10^{-10} \text{ m}$

According to Heisenberg uncertainty principle

$$\Delta p \cdot \Delta x = \frac{h}{4\pi}$$

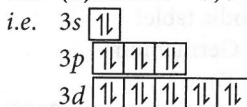
or $m\Delta v \Delta x = \frac{h}{4\pi}$

$$\Delta v = \frac{h}{4\pi m \Delta x} = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 6.63 \times 10^{-31} \times 1 \times 10^{-10}}$$

$$\Delta v = \frac{10^7}{4 \times 3.14}$$

$$\Delta v = 8 \times 10^5$$

10. (b) : For $n = 3, l = 0, 1, 2$



Out of these 18 electrons, 9 will have $m_s = +\frac{1}{2}$ and other 9 will have $m_s = -\frac{1}{2}$.

11. (d) : No. of protons = 11, hence atomic number = 11, so the element is Na. It has one electron less than the number of protons, hence it has a unit +ve charge.
 Given, no. of neutrons = 12

Mass number = No. of protons + No. of neutrons
 $= 11 + 12 = 23$

Therefore, the symbol of that species is $^{23}_{11}\text{Na}^+$.

12. (a) : Energy of one photon

$$= \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3.0 \times 10^8}{550 \times 10^{-9}} = 3.6 \times 10^{-19} \text{ J}$$

Energy absorbed per second by bulb = $100 \times 1 \times 3600$
 $(\because \text{Energy} = V \times I \times t)$

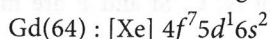
Let n photons be evolved per second.

$$n \times 3.6 \times 10^{-19} = 100 \times 3600$$

$$n = \frac{100 \times 3600}{3.6 \times 10^{-19}} = 1 \times 10^{24}$$

13. (a)

14. (d) : Electronic configuration of



So, total unpaired electrons = 8

$$\text{Sum of spin} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = 4$$

15. (e) : As effective nuclear charge = 2.60 and valence shell contain 3 electrons. Thus minimum no. of main shells for the given element are two i.e. ($n = 2$) and its configuration will be $1s^2 2s^2 2p^1$

Thus, the given element has 5 electrons in all

$\therefore$ No of electrons = Atomic number

Thus, atomic number of the element is 5.

16. (c) : Uncertainty principle is valid for microscopic particles. As one molecule of methane is considered as a microscopic particle, hence uncertainty principle is also valid for CH_4 molecule.

17. (a) : $E_n = \frac{-13.6}{n^2} \text{ eV}$
 $= -1.51 \text{ eV} (n = 3, \text{ for } 3s \text{ orbital})$

18. (c) : As we move towards outer shells, the energy increases but the difference between the successive shells decreases i.e.,

$$E_2 - E_1 > E_3 - E_2 > E_4 - E_3 \dots\dots$$

Hence, the emission of least energetic photon takes place during the transition from $n = 6$ energy level to $n = 5$ energy level.

19. (d) : $E = W_0 + KE$ [$\because E = \frac{hc}{\lambda}$]

In experiment 'A', $\frac{hc}{x/2} = \frac{hc}{x} + KE$

$$\therefore K.E. = \frac{2hc}{x} - \frac{hc}{x} = \frac{hc}{x}$$

In experiment 'B', $\frac{hc}{x/4} = \frac{hc}{x} + KE$

$$K.E. = \frac{4hc}{x} - \frac{hc}{x} = \frac{3hc}{x}$$

Ratio of kinetic energies of the released electrons in experiment 'B' to that in experiment 'A' = $\frac{3hc/x}{hc/x} = 3$

20. (a) : According to Heisenberg's uncertainty principle

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

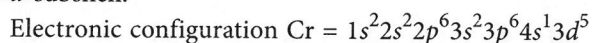
$$\Rightarrow \Delta x \cdot m\Delta v = \frac{h}{4\pi} \Rightarrow m = \frac{h}{4\pi \Delta x \cdot \Delta v}$$

Given : $\Delta x = 1 \times 10^{-10} \text{ m}$ $\Delta v = 1 \times 10^{-10} \text{ m s}^{-1}$

$$\therefore m = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 10^{-10} \times 10^{-10}}$$

$$m = 5.270 \times 10^{-15} \text{ kg}$$

21. (e) : $l = 1$ means p -subshell and $l = 2$ means d -subshell.



There are total 12 electrons in p -orbital and 5 electrons in d -orbital.



Classification of Elements and Periodicity in Properties

- Which of the following isoelectronic species has the smallest radius?
(a) Mg^{2+} (b) F^- (c) Na^+ (d) O^{2-}
(e) Al^{3+} (2024)
- Which of the following has the least atomic radius?
(a) B (b) C (c) N (d) O
(e) F (2024)
- Which of the following pair exhibits diagonal relationship?
(a) Li and Mg (b) Li and Na
(c) Mg and Al (d) B and P
(e) C and Cl (2024)
- The decreasing order of first ionisation enthalpy of the following elements is
(a) $\text{N} > \text{O} > \text{C} > \text{Be}$ (b) $\text{O} > \text{N} > \text{C} > \text{Be}$
(c) $\text{Be} > \text{C} > \text{O} > \text{N}$ (d) $\text{O} > \text{N} > \text{Be} > \text{C}$
(e) $\text{N} > \text{O} > \text{Be} > \text{C}$ (2024)
- The correct order of variation of first ionisation enthalpies is
(a) $\text{Ne} < \text{Xe} > \text{Li} > \text{K} < \text{Cs}$
(b) $\text{Xe} < \text{Li} < \text{K} < \text{Cs} < \text{Ne}$
(c) $\text{Cs} > \text{K} > \text{Li} > \text{Xe} > \text{Ne}$
(d) $\text{Li} > \text{K} > \text{Cs} > \text{Ne} > \text{Xe}$
(e) $\text{Ne} > \text{Xe} > \text{Li} > \text{K} > \text{Cs}$ (2023)
- The first ionisation enthalpy is the least in
(a) germanium (b) antimony
(c) tellurium (d) arsenic
(e) bismuth. (2021)
- Which one of the following elements is represented as Eka-silicon in Mendeleev's periodic table?
(a) Gallium (b) Germanium
(c) Aluminium (d) Tin
(e) Arsenic (2020)
- The IUPAC name of an element is Unbinilium. Its atomic number is
(a) 102 (b) 110 (c) 120 (d) 106
(e) 100 (2020)
- Which element has the highest first ionization potential?
(a) N (b) Ne (c) He (d) H
(e) Li (2018)
- Which statement(s) is (are) false for the periodic classification of elements?
(a) The properties of the elements are the periodic functions of their atomic numbers.
(b) Non-metallic elements are lesser in number than the metallic elements.
(c) The first ionization energies of the elements along a period do not vary in a regular manner with increase in atomic number.
(d) For transition elements, the d -electrons are filled monotonically with increase in atomic number.
(e) Both (c) and (d). (2018)
- The electronegativities of N, C, Si and P are in the order
(a) $\text{P} < \text{Si} < \text{C} < \text{N}$ (b) $\text{Si} < \text{P} < \text{N} < \text{C}$
(c) $\text{Si} < \text{P} < \text{C} < \text{N}$ (d) $\text{P} < \text{Si} < \text{N} < \text{C}$
(e) difficult to predict. (2018)

Answer Keys

1. (e) 2. (e) 3. (a) 4. (a) 5. (e) 6. (e) 7. (b) 8. (c) 9. (c) 10. (d)
11. (c)

Hints & Explanations

- (e) : The cation with the greater positive charge will have a smaller radius because of the greater attraction of the electrons to the nucleus. Anion with the greater negative charge will have the larger radius. Hence, Al^{3+} will have the smallest radius.
- (e) : F has the least atomic radius. As atomic size decreases on moving from left to right in period as shell remains the same but nuclear pull increases.
- (a) : Li and Mg exhibit diagonal relationship due to their similar ionic radii, and similarity in their properties.

4. (a): Correct order of 1st ionisation enthalpy of the following element is $N > O > C > Be$

${}_7N = 1s^2 2s^2 2p^3$ extra stability due to half-filled p -orbitals

${}_8O = 1s^2 2s^2 2p^4$

${}_6C = 1s^2 2s^2 2p^2$

${}_4Be = 1s^2 2s^2$

Ionisation enthalpy increases as we move across a period as size decreases, nuclear pull increases. But due to extra stability of half-filled electronic configuration, ionisation enthalpy of nitrogen is higher than oxygen.

5. (e): Noble gases generally have highest ionisation enthalpy. On moving down the group, $I.E$ decreases while across the period, it increases.

6. (e): Germanium: $I.E.$ (kJ/mol) – 761

Antimony: $I.E.$ (kJ/mol) – 834

Tellurium: $I.E.$ (kJ/mol) – 869

Arsenic: $I.E.$ (kJ/mol) – 947

Bismuth: $I.E.$ (kJ/mol) – 703

Ionisation energy decreases down the group and increases left to right in a period. On the basis of data, bismuth has least ionisation enthalpy.

7. (b): Eka-silicon is germanium.

8. (c): The IUPAC name for atomic number 120 is unbinilium and symbol is Ubn.

9. (c): Ionisation enthalpy decrease down the group and increases from left to right in a period.

So, the order of increasing first ionisation potential is

$Li < H < N < Ne < He$

10. (d): In principle, electrons are added one at a time to the penultimate d -orbitals but due to extra stability of d^5 and d^{10} configurations, two electrons appears to have entered the d -shell due to shifting of one electron from ns to $(n-1)d$ orbital.

11. (c): Electronegativity generally increases on moving across a period from left to right and decreases from top to bottom in a group.

So, the correct order is

$Si < P < C < N$

1.9 2.19 2.5 3.0



Chemical Bonding and Molecular Structure

- Which of the following molecule has the highest dipole moment?
(a) NH_3 (b) NF_3 (c) CCl_4 (d) BeF_2
(e) BF_3 (2024)
- For which of the following molecule, resonance structures are necessary to describe the bonding satisfactorily?
(a) Ozone
(b) Boron trifluoride
(c) Water
(d) Acetylene
(e) Phosphorous trichloride (2024)
- The bond order of O_2 molecule and its magnetic property are respectively
(a) 3, paramagnetic (b) 2, paramagnetic
(c) 3, diamagnetic (d) 1.5, paramagnetic
(e) 2, diamagnetic (2024)
- Which of the following molecule has the most polar bond?
(a) Cl_2 (b) HCl
(c) PCl_3 (d) N_2
(e) HF (2024)
- Strong intra-molecular hydrogen bond is present in
(a) water (b) hydrogen fluoride
(c) *o*-cresol (d) *o*-nitrophenol
(e) ammonia. (2024)
- Which of the following molecule has a Lewis structure that does not obey the octet rule?
(a) HCN (b) CS_2
(c) NO (d) CCl_4
(e) PF_3 (2024)
- Which of the following has square planar structure?
(a) NH_4^+ (b) XeF_4
(c) CCl_4 (d) SiCl_4
(e) CH_4 (2024)
- Which of the following molecule is paramagnetic?
(a) O_2 (b) C_2
(c) N_2 (d) F_2
(e) H_2 (2024)
- Which of the following compound has the lowest boiling point?
(a) Carbon disulphide
(b) Water (c) Ethanol
(d) Benzene (e) Chloroform (2024)
- The molecule which has see saw in structure is
(a) NH_3 (b) SF_4 (c) CCl_4 (d) SiCl_4
(e) BrF_5 (2024)
- The valence electron MO configuration of C_2 (atomic number of C = 6) molecule is
(a) $(\sigma 2s)^3 (\sigma^* 2s)^3 (\pi 2p)^2$
(b) $(\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p)^4$
(c) $(\sigma 2s)^2 (\sigma^* 2s)^3 (\pi 2p)^3$
(d) $(\sigma 2s)^2 (\sigma^* 2s)^4 (\pi 2p)^2$
(e) $(\sigma 2s)^2 (\sigma^* 2s)^1 (\pi 2p)^5$ (2024)
- Which of the following statements is wrong?
(a) The bond order of He_2 is zero; so He_2 molecule is unstable.
(b) Li_2 molecule is diamagnetic.
(c) O_2 molecule contains two unpaired electrons and is paramagnetic.
(d) C_2 molecule is paramagnetic in vapour phase.
(e) H_2 molecule has no unpaired electrons. (2023)
- Which one of the following molecules contains an incomplete octet of the central atom?
(a) SF_6 (b) AlCl_3
(c) CH_4 (d) PF_5
(e) H_2O (2022)
- Which one of the following reactions involves change from sp^2 to sp^3 hybridisation of the central atom?
(a) $\text{CH}_4 + 2\text{Cl}_2 \rightarrow \text{CH}_2\text{Cl}_2 + 2\text{HCl}$
(b) $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$
(c) $\text{AlCl}_3 + \text{Cl}^- \rightarrow \text{AlCl}_4^-$
(d) $\text{H}_2\text{O} + \text{H}^+ \rightarrow \text{H}_3\text{O}^+$
(e) $\text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5$ (2022)
- In which one of the following, sp^2 hybridisation is involved in the central atom?
(a) NH_3 (b) BCl_3
(c) ClF_3 (d) PCl_3
(e) PH_3 (2021)

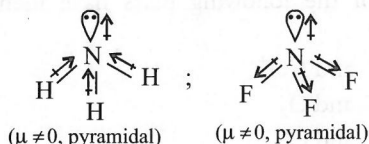
16. NO^+ has bond order
 (a) 2 (b) 2.5
 (c) 3 (d) 3.5
 (e) 4 (2019)
17. The carbon atoms in calcium carbide are held by
 (a) ionic bonds
 (b) two sigma bonds
 (c) two sigma and one coordinate bond
 (d) one sigma and two π bonds
 (e) one sigma and one π bond. (2019)
18. According to the VSEPR theory, the shape of ClO_3^- would be
 (a) linear
 (b) triangular planar
 (c) pyramidal
 (d) square planar
 (e) angular. (2019)
19. Maximum number of covalent bonds formed by N and P are
 (a) 3, 5 (b) 3, 6
 (c) 3, 4, 5 (d) 3, 4, 6
 (e) none of the above. (2018)
20. Consider the following species,
 1. $[\text{O}_2]^{2-}$ 2. $[\text{CO}]^+$
 3. $[\text{O}_2]^+$
 Among these, sigma bond alone is present in
 (a) 1 alone (b) 2 alone
 (c) 3 alone (d) 1 and 2
 (e) 1, 2 and 3 (2018)
21. The common features among CO, CN^- and NO_2^+ are
 (a) bond order three and isoelectronic
 (b) bond order three and weak field ligands
 (c) bond order two and π -acceptors
 (d) bond order three and π -donors
 (e) isoelectronic and strong field ligands. (2017)
22. Which of the following is covalent?
 (a) NaCl (b) KCl
 (c) BeCl_2 (d) MgCl_2
 (e) CaCl_2 (2017)
23. Among the following, the molecule that will have the highest dipole moment is
 (a) H_2 (b) HI
 (c) HBr (d) HCl
 (e) HF (2017)
24. Which of the following pairs have identical bond order?
 (a) CN^- and NO^+
 (b) CN^- and O_2^-
 (c) CN^- and CN^+
 (d) NO^+ and O_2^-
 (e) O_2^- and CN^+ (2017)
25. Hybridisation of carbon in CH_3^-
 (a) sp^2 (b) sp^3
 (c) sp^3d (d) sp^3d^2
 (e) sp^2d^3 (2017)
26. Identify the T-shaped molecule in the following :
 (a) BF_3 (b) NH_3
 (c) NF_3 (d) ClF_3
 (e) PCl_3 (2016)
27. Which one of the following molecules has the least dipole moment?
 (a) H_2O (b) BeF_2
 (c) NH_3 (d) NF_3
 (e) BF_3 (2016)
28. An odd electron molecule among the following is
 (a) CO (b) SO_2
 (c) CO_2 (d) NO
 (e) OF_2 (2015)
29. Which of the following changes in the respective bond order values are caused by removal of an electron from N_2 and F_2 molecules?
 (a) Decrease by 0.5 in both
 (b) Increase by 0.5 in both
 (c) Increase by 0.5 in the former and decrease by 0.5 in the later
 (d) Decrease by 0.5 in the former and increase by 0.5 in the later
 (e) No change in both (2015)
30. The hybridised state of bromine in bromine pentafluoride is
 (a) sp^3d (b) dsp^3
 (c) d^2sp^3 (d) sp^2d
 (e) sp^3d^2 (2015)

Answer Keys

1. (a) 2. (a) 3. (b) 4. (e) 5. (d) 6. (c) 7. (b) 8. (a) 9. (a) 10. (b)
 11. (b) 12. (d) 13. (b) 14. (c) 15. (b) 16. (c) 17. (d) 18. (c) 19. (a) 20. (a)
 21. (a) 22. (c) 23. (e) 24. (a) 25. (b) 26. (d) 27. (b, e) 28. (d) 29. (d) 30. (e)

Hints & Explanations

1. (a) : The dipole moment of NH_3 is the highest.



In NH_3 , H is less electronegative than N and hence dipole moment of each N—H bond is towards N and create high net dipole moment whereas in NF_3 , F is more electronegative than N, the dipole moment of each N—F bond is opposite to that of lone pair, hence reducing the net dipole moment.

CCl_4 , BeF_2 and BF_3 have zero dipole moments.

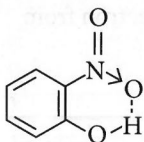
2. (a) : The concept of resonance was introduced to deal with the type of difficulty experienced in the depiction of accurate structures of molecules like O_3 .

3. (b) : O_2 : $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 = \pi 2p_y^2$
 $\pi^* 2p_x^1 = \pi^* 2p_y^1$

Bond order = $\frac{1}{2} (10 - 6) = 2$ (O_2 is paramagnetic due to the presence of 2 unpaired electron).

4. (e) : Due to the high electronegativity difference between H and F, H—F has the most polar bond.

5. (d) : The hydrogen bonding which takes place within a molecule is called intramolecular hydrogen bonding.



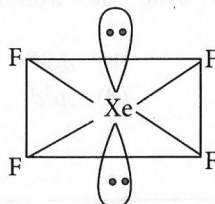
o-Nitrophenol

6. (c) : NO does not obey octet rule.

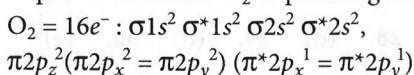


Odd electron molecule

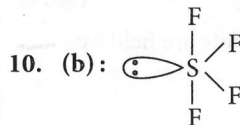
7. (b) : Structure of XeF_4 is square planar



8. (a) : According to M.O. theory, two unpaired electrons are present in the π^* orbitals of O_2 . Due to presence of unpaired electrons O_2 is paramagnetic.



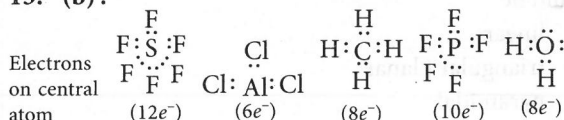
9. (a) : Carbon disulphide has lowest boiling point.



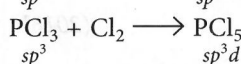
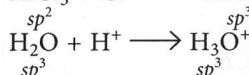
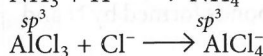
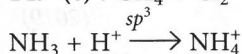
10. (b) : M.O. configuration of C_2 (12) molecule is
 $(\sigma 1s^2)(\sigma^* 1s^2)(\sigma 2s^2)(\sigma^* 2s^2)(\pi 2p_x^2 = \pi 2p_y^2)$

12. (d) : C_2 molecule is diamagnetic in vapour phase.

13. (b) :



14. (c) : $\text{CH}_4 + \text{Cl}_2 \longrightarrow \text{CH}_3\text{Cl} + 2\text{HCl}$



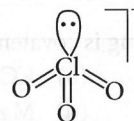
15. (b) : NH_3 : sp^3 BCl_3 : sp^2
 ClF_3 : sp^3d PCl_3 : sp^3
 PH_3 : sp^3

16. (c) : NO^+ (14) : $\text{KK } \sigma(2s)^2, \sigma^*(2s)^2, \sigma 2p_z^2,$
 $\pi(2p_x)^2 = \pi(2p_y)^2$

Bond order = $\frac{(8-2)}{2} = 3$

17. (d) : CaC_2 has the structure : $\text{Ca}^{2+} [\text{C} \equiv \text{C}]^{2-}$
 Thus, the carbon atoms are held by one sigma and two π bonds.

18. (c) : ClO_3^- contains 3 bond pairs and 1 lone pair, hence it has sp^3 hybridisation and pyramidal structure.



19. (a) : Nitrogen does not have vacant d -orbitals so maximum number of covalent bonds it can form is 3 while phosphorus can form five covalent bonds due to presence of vacant d -orbitals.

20. (a) : $[\text{O}=\text{O}]^{2-}$ $[\text{C} \equiv \text{O}]^+$ $[\text{O} \equiv \text{O}]^+$
 O_2^{2-} CO^+ O_2^+

Thus, only O_2^{2-} have σ bonds alone.

21. (a) : Note : Read NO_2^+ as NO^+ in the question.

Total no. of electrons in $\text{CO} = 6 + 8 = 14$

Total no. of electrons in $\text{CN}^- = 6 + 7 + 1 = 14$

Total no. of electrons in $\text{NO}^+ = 7 + 8 - 1 = 14$

Molecular orbital configuration for each will be same, i.e.,
 $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10 - 4}{2} = 3$$

22. (c) : BeCl_2 is a covalent compound, whereas all others are ionic compounds.

23. (e) : Greater the difference in electronegativity values of the two atoms forming the bond, higher will be the dipole moment of the molecule. 'F' has highest electronegativity value. Thus, HF will have the highest dipole moment.

24. (a) : Total number of electrons in $\text{CN}^- = 6 + 7 + 1 = 14$
 Total number of electrons in $\text{NO}^+ = 7 + 8 - 1 = 14$
 Total number of electrons in $\text{O}_2^- = 2 \times 8 + 1 = 17$
 Total number of electrons in $\text{CN}^+ = 6 + 7 - 1 = 12$
 Thus, CN^- and NO^+ have identical bond order because both CN^- and NO^+ contains same number of electrons.

25. (b) : Carbon has sp^3 hybridisation in CH_3^- .

26. (d) : BF_3 : sp^2 hybridisation, trigonal planar

NH_3 : sp^3 hybridisation, pyramidal

NF_3 : sp^3 hybridisation, pyramidal

ClF_3 : sp^3d hybridisation, T-shaped

PCl_3 : sp^3 hybridisation, pyramidal

27. (b, e) : BeF_2 has linear shape and BF_3 is symmetrical hence, both have zero dipole moment.

28. (d) : NO molecule is paramagnetic and it fails to follow Lewis octet rule.



29. (d) : Electronic configuration of N_2 molecule is
 $KK[\sigma(2s)]^2 [\sigma^*(2s)]^2 [\pi(2p_x)]^2 = [\pi(2p_y)]^2 [\sigma(2p_z)]^2$

$$\text{B.O.} = \frac{1}{2} (N_b - N_a) = \frac{1}{2} (8 - 2) = 3$$

For the formation of N_2^+ , the bond order changes to 2.5.

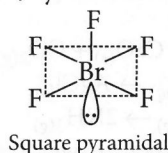
Electronic configuration of F_2 molecule is

$$KK[\sigma(2s)]^2 [\sigma^*(2s)]^2 [\sigma(2p_z)]^2 [\pi(2p_x)]^2 = [\pi(2p_y)]^2 [\pi^*(2p_x)]^2 = [\pi^*(2p_y)]^2$$

$$\text{B.O.} = \frac{1}{2} (8 - 6) = 1$$

For the formation of F_2^+ , the bond order changes to 1.5.

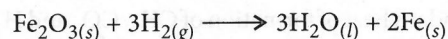
30. (e) : In BrF_5 , there are five σ bonds and one lone pair of electrons. Therefore, hybridisation of Br in BrF_5 is sp^3d^2 .



Thermodynamics

- Enthalpy of combustion of ethylene gas at constant pressure of 1 atm and at 300 K is $-1410 \text{ kJ mol}^{-1}$. The enthalpy change for the reaction at constant volume and at the same temperature is about ($R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$)
 - $-1405 \text{ kJ mol}^{-1}$
 - $-1415 \text{ kJ mol}^{-1}$
 - $-1407.5 \text{ kJ mol}^{-1}$
 - $-1417.5 \text{ kJ mol}^{-1}$
 - $-1402.5 \text{ kJ mol}^{-1}$
 (2024)
- ΔS would be negative for which of the following reactions?
 - $\text{CaCO}_{3(s)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(g)}$
 - $\text{Ag}_{(aq)}^+ + \text{Cl}_{(aq)}^- \rightarrow \text{AgCl}_{(s)}$
 - $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$
 Choose the correct answer from the codes given below:
 - I and III only
 - II and III only
 - I only
 - III only
 - I, II, and III
 (2024)
- The standard molar entropies of $\text{SO}_{2(g)}$, $\text{SO}_{3(g)}$ and $\text{O}_{2(g)}$ are 250 J K^{-1} , 257 J K^{-1} and are 205 J K^{-1} respectively. Calculate standard molar entropy change for the reaction, $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{SO}_{3(g)}$
 - -198 J K^{-1}
 - -191 J K^{-1}
 - 198 J K^{-1}
 - 191 J K^{-1}
 - -1219 J K^{-1}
 (2024)
- Which of the following statement is incorrect?
 - The greater the disorder in an isolated system, the higher is the entropy.
 - The crystalline solid state of a substance is the state of lowest entropy.
 - Entropy is not the measure of average chaotic motion of particles in the system.
 - The gaseous state of a substance is state of highest entropy.
 - ΔS is related to q and T for a reversible reaction as $\Delta S = q_{\text{rev}}/T$.
 (2024)
- The total enthalpy change when 1 mol of water at 100°C and 1 bar pressure is converted to ice at 0°C is _____.
 (Enthalpy of fusion of ice = 6.00 kJ mol^{-1} , heat capacity of water = $4.2 \text{ J K}^{-1} \text{ g}^{-1}$, molar mass of $\text{H}_2\text{O} = 18 \text{ g mol}^{-1}$)
 - $-7.56 \text{ kJ mol}^{-1}$
 - $-6.00 \text{ kJ mol}^{-1}$
 - $-13.56 \text{ kJ mol}^{-1}$
 - -756 kJ mol^{-1}
 - $-1.356 \text{ kJ mol}^{-1}$
 (2024)
- Which of the following are the conditions for a reaction spontaneous at all temperatures?
 - $\Delta_r H > 0$; $\Delta_r S > 0$
 - $\Delta_r H < 0$; $\Delta_r S > 0$
 - $\Delta_r H < 0$; $\Delta_r S < 0$
 - $\Delta_r H = 0$; $\Delta_r S < 0$
 - $\Delta_r H = 0$; $\Delta_r S = 0$
 (2024)
- In a combustion reaction, heat change during the formation of 40 g of carbon dioxide from carbon and dioxygen gas is (Enthalpy of combustion of carbon = -396 kJ mol^{-1})
 - 320 kJ
 - 320 kJ
 - 360 kJ
 - 360 kJ
 - 240 kJ
 (2024)
- Which of the following is true for a reaction is spontaneous only at high temperature?
 - $\Delta_r H^\circ < 0$, $\Delta_r S^\circ > 0$, $\Delta_r G^\circ < 0$
 - $\Delta_r H^\circ > 0$, $\Delta_r S^\circ > 0$, $\Delta_r G^\circ > 0$
 - $\Delta_r H^\circ > 0$, $\Delta_r S^\circ > 0$, $\Delta_r G^\circ < 0$
 - $\Delta_r H^\circ > 0$, $\Delta_r S^\circ < 0$, $\Delta_r G^\circ < 0$
 - $\Delta_r H^\circ < 0$, $\Delta_r S^\circ < 0$, $\Delta_r G^\circ < 0$
 (2024)
- In a process, 600 J of heat is absorbed by a system and 375 J of work is done by the system. The change in internal energy of the process is
 - 975 J
 - 225 J
 - 975 J
 - 985 J
 - 225 J
 (2024)
- Which is the wrong statement from the following lists?
 - No work is done during free expansion of an ideal gas for both reversible and irreversible processes.
 - The density and pressure are extensive properties but the enthalpy and heat capacity are intensive properties.
 - The change in enthalpy (ΔH) is negative for exothermic reactions but is positive for endothermic reactions.
 - The difference between change in enthalpy (ΔH) and the internal energy (ΔU) is not significant for solids and liquids, but significant for gases.
 - The standard enthalpy change of fusion of CH_3COCH_3 is higher than that of N_2 .
 (2023)

11. In which of the following, entropy decreases?
 (a) Liquid water is converted to gas.
 (b) Liquid water crystallizes to ice.
 (c) $\text{H}_{2(g)} \rightarrow 2\text{H}_{(g)}$
 (d) $\text{NH}_4\text{Cl}_{(s)} \rightarrow \text{NH}_{3(g)} + \text{HCl}_{(g)}$
 (e) Temperature of $\text{NaCl}_{(s)}$ raises from 298 to 517 K.
 (2023)
12. The standard enthalpy of formation of $\text{CH}_{4(g)}$, $\text{CO}_{2(g)}$ and $\text{H}_2\text{O}_{(l)}$ are -75 kJ mol^{-1} , -393 kJ mol^{-1} and -286 kJ mol^{-1} respectively. The amount of heat liberated (in kJ) when 3.2 g of methane gas is burnt under standard conditions is
 (a) 89 (b) 278 (c) 890 (d) 965
 (e) 178 (2022)
13. Which one of the following is the correct relation between C_p and C_v for one mole of an ideal gas? (R is molar gas constant)
 (a) $C_p = C_v - R$ (b) $C_p = C_v + R$
 (c) $C_p = R - C_v$ (d) $C_p = C_v \times R$
 (e) $C_p = C_v/R$ (2022)
14. Predict in which of the following, entropy decreases?
 (a) A liquid crystallizes into a solid.
 (b) Temperature of a crystalline solid is raised from 0 K to 115 K.
 (c) $2\text{NaHCO}_{3(s)} \rightarrow \text{Na}_2\text{CO}_{3(s)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(g)}$
 (d) $\text{H}_{2(g)} \rightarrow 2\text{H}_{(g)}$
 (e) $2\text{SO}_{3(g)} \rightarrow 2\text{SO}_{2(g)} + \text{O}_{2(g)}$ (2021)
15. The standard enthalpies of formation of $\text{H}_2\text{O}_{(l)}$ and $\text{CO}_{2(g)}$ are respectively -286 kJ mol^{-1} and -394 kJ mol^{-1} . If the standard heat of combustion of $\text{CH}_{4(g)}$ is -891 kJ mol^{-1} , then the standard enthalpy of formation of $\text{CH}_{4(g)}$ is
 (a) -75 kJ mol^{-1} (b) $+75 \text{ kJ mol}^{-1}$
 (c) -211 kJ mol^{-1} (d) $+211 \text{ kJ mol}^{-1}$
 (e) $-1571 \text{ kJ mol}^{-1}$ (2020)
16. In which one of the following reactions, entropy decreases?
 (a) Sodium chloride is dissolved in water.
 (b) Water is heated from 303 K to 353 K.
 (c) Sodium bicarbonate is decomposed to $\text{Na}_2\text{CO}_{3(s)}$, $\text{CO}_{2(g)}$ and $\text{H}_2\text{O}_{(g)}$.
 (d) Water crystallises into ice.
 (e) Dihydrogen molecule is decomposed into hydrogen atoms. (2020)
17. An ideal gas "A" having volume of 1 L at 27 °C is kept in a container having movable piston and adiabatic walls in ambient condition. If 1.33 L atm of energy is supplied inside the system, find out the final temperature of the system.
 (a) 399 K (b) 499 K
 (c) 599 K (d) 299 K
 (e) 450 K (2019)
18. The standard heat of formation of CH_4 , CO_2 and $\text{H}_2\text{O}_{(l)}$ are -76.2 , -394.8 and $-285.82 \text{ kJ mol}^{-1}$, respectively. Heat of vaporization of water is 44 kJ mol^{-1} . Calculate the amount of heat evolved when 22.4 L of CH_4 kept under normal conditions is oxidized into its gaseous products.
 (a) 802 kJ (b) 878.4 kJ
 (c) 702 kJ (d) 788.4 kJ
 (e) 500 kJ (2019)
19. One mole of ethanol is produced reacting graphite, H_2 and O_2 together. The standard enthalpy of formation is $-277.7 \text{ kJ mol}^{-1}$. Calculate the standard enthalpy of the reaction when 4 moles of graphite is involved.
 (a) -277.7 (b) -555.4
 (c) -138.85 (d) -69.42
 (e) -1110.8 (2018)
20. Which of the following process best describes atomization of $\text{CH}_{4(g)}$?
 (a) Exothermic (b) Endothermic
 (c) Non-spontaneous (d) Spontaneous
 (e) Both (b) and (c) (2018)
21. Which of the following can help predict the rate of a reaction if the standard Gibbs' free energy of reaction ($\Delta_r G^\circ$) is known?
 (a) Equilibrium constant
 (b) $\Delta_r H^\circ$
 (c) $\Delta_r U^\circ$
 (d) Heat liberated during the course of reaction in calorimeter.
 (e) Both (b) and (a) (2018)
22. For the process;
 $\text{A}(l, 0.05 \text{ atm}, 32^\circ\text{C}) \rightarrow \text{A}(g, 0.05 \text{ atm}, 32^\circ\text{C})$
 The correct set of thermodynamic parameters is
 (a) $\Delta G = 0$ and $\Delta S = -ve$
 (b) $\Delta G = 0$ and $\Delta S = +ve$
 (c) $\Delta G = +ve$ and $\Delta S = 0$
 (d) $\Delta G = -ve$ and $\Delta S = 0$
 (e) $\Delta G = 0$ and $\Delta S = 0$ (2017)
23. Mixing of N_2 and H_2 form an ideal gas mixture at room temperature in a container. For this process, which of the following statements is true?
 (a) $\Delta H = 0$, $\Delta S_{\text{surrounding}} = 0$, $\Delta S_{\text{system}} = 0$ and $\Delta G = -ve$
 (b) $\Delta H = 0$, $\Delta S_{\text{surrounding}} = 0$, $\Delta S_{\text{system}} > 0$ and $\Delta G = -ve$
 (c) $\Delta H > 0$, $\Delta S_{\text{surrounding}} = 0$, $\Delta S_{\text{system}} > 0$ and $\Delta G = -ve$
 (d) $\Delta H < 0$, $\Delta S_{\text{surrounding}} > 0$, $\Delta S_{\text{system}} < 0$ and $\Delta G = -ve$
 (e) $\Delta H = 0$, $\Delta S_{\text{surrounding}} = 0$, $\Delta S_{\text{system}} < 0$ and $\Delta G = -ve$ (2017)
24. The standard enthalpy of formation of $\text{H}_2\text{O}_{(l)}$ and $\text{Fe}_2\text{O}_{3(s)}$ are respectively -286 kJ mol^{-1} and -824 kJ mol^{-1} . What is the standard enthalpy change for the following reaction?



- (a) -538 kJ mol^{-1} (b) $+538 \text{ kJ mol}^{-1}$
 (c) -102 kJ mol^{-1} (d) $+34 \text{ kJ mol}^{-1}$
 (e) -34 kJ mol^{-1} (2016)

25. The enthalpy change for a reaction at equilibrium is $-20.5 \text{ kJ mol}^{-1}$. Then the entropy change for this equilibrium at 410 K is

- (a) $+50 \text{ JK}^{-1}\text{mol}^{-1}$ (b) $+55 \text{ JK}^{-1}\text{mol}^{-1}$
 (c) $+75 \text{ JK}^{-1}\text{mol}^{-1}$ (d) $-50 \text{ JK}^{-1}\text{mol}^{-1}$
 (e) $-55 \text{ JK}^{-1}\text{mol}^{-1}$ (2015)

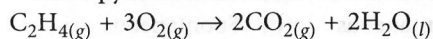
26. The enthalpy of combustion of glucose (mol. wt: 180 g mol^{-1}) is $-2840 \text{ kJ mol}^{-1}$. Then the amount of heat evolved when 0.9 g of glucose is burnt, will be
 (a) 14.2 kJ (b) 14.2 J (c) 28.4 kJ (d) 1420 kJ
 (e) 142 kJ (2015)

Answer Keys

1. (a) 2. (b) 3. (b) 4. (c) 5. (c) 6. (b) 7. (c) 8. (c) 9. (e) 10. (b)
 11. (b) 12. (e) 13. (b) 14. (a) 15. (a) 16. (d) 17. (a) 18. (a) 19. (b) 20. (e)
 21. (a) 22. (b) 23. (b) 24. (e) 25. (d) 26. (a)

Hints & Explanations

1. (a) : Enthalpy of combustion at constant pressure (ΔH) = enthalpy of combustion at constant volume (ΔV) + ΔnRT



For given reaction, $\Delta n = 2 - 3 - 1 = -2 \text{ mol}$

Enthalpy at constant pressure = $-1410 \text{ kJ mol}^{-1}$

$$\Delta U = \Delta H - \Delta nRT$$

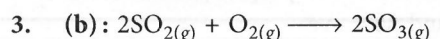
$$= -1410 - (-2 \text{ mol} \times 8.314 \times 10^{-3} \text{ kJ mol}^{-1} \text{ K}^{-1} \times 300 \text{ K})$$

$$= -1410 + 4.9884$$

$$= -1405.01$$

$$\approx -1405 \text{ kJ mol}^{-1}$$

2. (b) : Entropy is a measure of randomness or disorder of a system. If randomness decreases, entropy decreases. Gaseous molecules have greater randomness than solid molecules and as the number of gaseous molecules increases, entropy increases. Thus, for reaction (I), ΔS is positive and for reactions (II) and (III), ΔS is negative.



$$\Delta_r S^\circ = \sum S^\circ(\text{Products}) - \sum S^\circ(\text{Reactants})$$

$$= 2S^\circ_{\text{SO}_3} - (2S^\circ_{\text{SO}_2} + S^\circ_{\text{O}_2})$$

$$= 2 \times 257 - (2 \times 250 + 205)$$

$$= -191 \text{ J K}^{-1}$$

4. (c) : Entropy is measure of randomness. It is a measure of average chaotic motion of particles in the system.

5. (c) : Total enthalpy change involved in the transformation.

(1) Energy change in transformation of 1 mole of water at $100^\circ\text{C} \rightarrow 1 \text{ mole of H}_2\text{O at } 0^\circ\text{C}$.

$$\Delta H = m \times q \times \Delta T = 18 \times 4.2 \times (-100)$$

$$= -7.56 \text{ kJ mol}^{-1}$$

(2) Enthalpy change of H_2O at 0°C to ice at 0°C .

$$\Delta_f H = -6.00 \text{ kJ mol}^{-1}$$

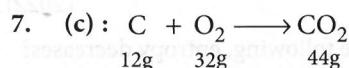
$$\text{Total enthalpy change } -6.00 + (-7.56) = -13.56 \text{ kJ/mol}$$

6. (b) : $\Delta G = -ve$ for spontaneous reaction

$$\Delta G = \Delta H - T\Delta S$$

If $\Delta H < 0$ (negative) and $\Delta S > 0$ (positive)

So, at all temperature $\Delta G = -ve$



1 mole of C reacts with 1 mole of O_2 to give 44 g of CO_2

$$\Delta H_{\text{comb}} = -396 \text{ kJ mol}^{-1}$$

When 44 g of CO_2 is produced, -396 kJ/mol energy released

$$\text{When 40 g of } \text{CO}_2 \text{ is produced, } -\frac{396}{44} \times 40$$

$$= -360 \text{ kJ/mol energy released}$$

8. (c) : $\Delta G = (-)$ for spontaneous reaction

$$\Delta G = \Delta H - T\Delta S$$

if $\Delta H = (+ve)$, $\Delta S = (+ve)$

Then ΔG is $-ve$ only at high T .

Hence, $\Delta_r H^\circ > 0$, $\Delta_r S^\circ > 0$, $\Delta_r G^\circ < 0$.

9. (e) : According to 1st law of thermodynamics

$$\Delta U = q + W$$

Heat absorbed by system = $q = +600 \text{ J}$

Work is done by the system $W = -375 \text{ J}$

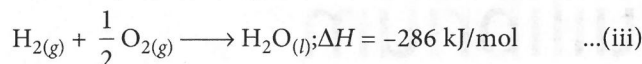
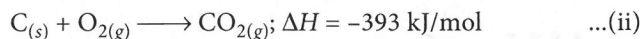
$$\Delta U = +600 - 375 = 225 \text{ J}$$

10. (b) : Density and pressure are intensive property as they depend only upon the nature of the substance and are independent of the amount of the substance.

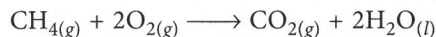
Enthalpy and heat capacity are extensive property as they depend upon the quantity of the matter contained in the system.

11. (b) : When liquid water crystallizes to solid ice, the entropy decreases as randomness decreases. In all other cases, randomness increases and hence, entropy increases.

12. (e) : Given : $\text{C}_{(s)} + 2\text{H}_{2(g)} \longrightarrow \text{CH}_{4(g)}$; $\Delta H = -75 \text{ kJ/mol}$
 ... (i)



Equations (ii) + 2(iii) - (i) will give our desired equation



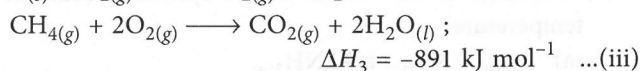
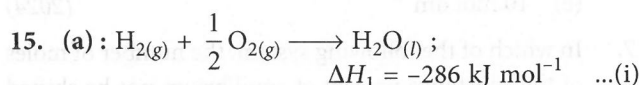
$$\Delta H = -393 + 2 \times (-286) - (-75) = -890 \text{ kJ/mol}$$

1 mol *i.e.* 16 g CH_4 releases 890 kJ of heat.

$$\text{Then 3.2 g methane will release} = \frac{890}{16} \times 3.2 = 178 \text{ kJ}$$

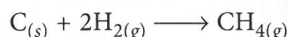
$$13. (b): C_p - C_v = R$$

14. (a): When liquid crystallizes into solid, entropy decreases as randomness decreases.



Required reaction is, $C_{(s)} + 2H_{2(g)} \longrightarrow CH_{4(g)}; \Delta H = ?$

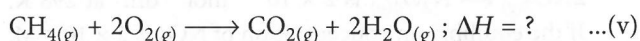
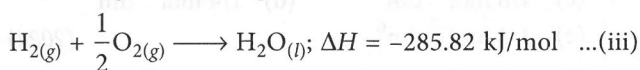
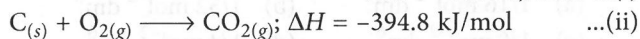
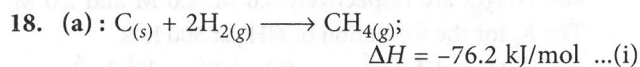
On applying operation, (i) $\times 2$ + (ii) - (iii), we get



$$\Delta H = 2 \times (-286) + (-394) - (-891) = -75 \text{ kJ mol}^{-1}$$

16. (d): When water freezes into ice, the randomness or disorderness decreases *i.e.*, entropy decreases.

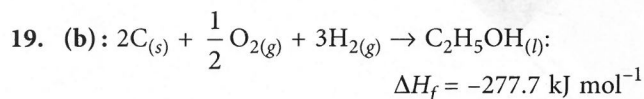
17. (a)



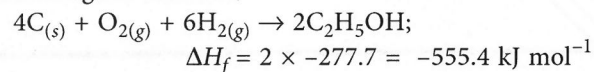
On applying operation, (ii) + 2 $\times$ (iii) + 2 $\times$ (iv) - (i)

We get equation (v),

$$\text{Thus, } \Delta H = -394.8 + (2 \times -285.82) + 2 \times 44 - (-76.2) \\ = -394.8 - 571.64 + 88 + 76.2 = -802.24 \text{ kJ}$$



By doubling the reaction,



20. (e)

21. (a)



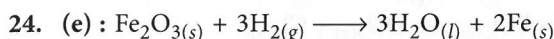
Liquid A is changing into gaseous A, thus, randomness is increasing, *i.e.*, entropy change (ΔS) is positive.

$$K_p = \frac{P_{A(g)}}{P_{A(l)}} = \frac{0.05}{0.05} = 1$$

$$\Delta G^\circ = -RT \ln K = -RT \ln 1 = 0$$

Thus, the system is in equilibrium.

23. (b)



$$\Delta_r H^\circ = \sum \Delta_f H^\circ_{(\text{Products})} - \sum \Delta_f H^\circ_{(\text{Reactants})}$$

$$\Delta_r H^\circ = 3(-286) - (-824) \quad [\because \Delta_f H^\circ \text{ for } Fe_{(s)}, H_{2(g)} = 0] \\ = -858 + 824 = -34 \text{ kJ mol}^{-1}$$

$$25. (d): \text{At equilibrium } \Delta S = \frac{\Delta H}{T}$$

$$\text{Given: } \Delta H = -20.5 \text{ kJ/mol} = -20500 \text{ J/mol} \\ T = 410 \text{ K}$$

$$\Delta S = \frac{-20500}{410} = -50 \text{ J K}^{-1} \text{ mol}^{-1}$$

26. (a): 180 g glucose on combustion evolves 2840 kJ heat.

$$\therefore 0.9 \text{ g glucose will evolve } \frac{2840 \times 0.9}{180} = 14.2 \text{ kJ heat}$$



Equilibrium

- Which of the following aqueous mixture is a buffer solution?
 - Acetic acid + ammonium chloride
 - Hydrochloric acid + potassium acetate
 - Acetic acid + sodium chloride
 - Acetic acid + sodium acetate
 - Sodium hydroxide + potassium acetate

(2024)
- In which of the following equilibrium, increase in pressure shift the equilibrium in the forward direction?
 - $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$
 - $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$
 - $\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)}$
 - $\text{CO}_{(g)} + 3\text{H}_{2(g)} \rightleftharpoons \text{CH}_{4(g)} + \text{H}_2\text{O}_{(g)}$
 - $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_2(g)$

(2024)
- For which of the following equilibria, $K_p = K_c$?
 - $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$
 - $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$
 - $\text{N}_2\text{O}_{4(g)} \rightleftharpoons 2\text{NO}_{2(g)}$
 - $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$
 - $\text{H}_{2(g)} + \text{Br}_{2(g)} \rightleftharpoons 2\text{HBr}_{(g)}$

(2024)
- Equal volumes of pH 3, 4 & 5 are mixed in a container. The concentration of H^+ in the mixture is (Assume there is no change in the volume during mixing)
 - $1 \times 10^{-3} \text{ M}$
 - $3.7 \times 10^{-4} \text{ M}$
 - $1 \times 10^{-4} \text{ M}$
 - $3.7 \times 10^{-5} \text{ M}$
 - $3 \times 10^{-5} \text{ M}$

(2024)
- The reaction, $\text{H}_2\text{O}_{(g)} + \text{Cl}_2\text{O}_{(g)} \rightleftharpoons 2\text{HOCl}_{(g)}$ is allowed to attain equilibrium at 400 K. At equilibrium the partial pressure of $\text{H}_2\text{O}_{(g)}$ is 300 mm of Hg, and those of $\text{Cl}_2\text{O}_{(g)}$ and $\text{HOCl}_{(g)}$ are 20 mm of Hg and 60 mm Hg respectively. the value of K_p for the reaction at 300 K is
 - 36
 - 6.0
 - 60
 - 3.6
 - 0.60

(2024)
- $\text{PCl}_{5(g)}$, $\text{PCl}_{3(g)}$ and $\text{Cl}_{2(g)}$ are at equilibrium at 500 K. The equilibrium concentrations of $\text{PCl}_{3(g)}$, $\text{Cl}_{2(g)}$ and $\text{PCl}_{5(g)}$ are respectively 4.0 M, 4.0 M and 2.0 M. Calculate K_c for the reaction,

$$\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$$
 - 2 mol dm^{-3}
 - 4 mol dm^{-3}
 - 6 mol dm^{-3}
 - 8 mol dm^{-3}
 - 10 mol dm^{-3}

(2024)
- In which of the following system, the number of moles of the substance present at equilibrium not be shifted by change in the volume of the system at constant temperature?
 - $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$
 - $\text{PCl}_{3(g)} + \text{Cl}_{2(g)} \rightleftharpoons \text{PCl}_{5(g)}$
 - $\text{CO}_{(g)} + 3\text{H}_{2(g)} \rightleftharpoons \text{CH}_{4(g)}$
 - $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$
 - $\text{NO}_{2(g)} + \text{SO}_{2(g)} \rightleftharpoons \text{SO}_{3(g)} + \text{NO}_{(g)} + \text{H}_2\text{O}_{(g)}$

(2024)
- For the equilibrium at 500 K, $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$, the equilibrium concentrations of $\text{N}_{2(g)}$, $\text{H}_{2(g)}$ and $\text{NH}_{3(g)}$ are respectively 4.0 M, 2.0 M and 2.0 M. The K_c for the formation of NH_3 at 500 K is
 - $1/16 \text{ mol}^{-2} \text{ dm}^6$
 - $1/32 \text{ mol}^{-2} \text{ dm}^6$
 - $1/8 \text{ mol}^{-2} \text{ dm}^6$
 - $1/4 \text{ mol}^{-2} \text{ dm}^6$
 - $1/2 \text{ mol}^{-2} \text{ dm}^6$

(2024)
- The value of K_c for the equilibrium reaction $2\text{NO}_{2(g)} \rightleftharpoons \text{N}_2\text{O}_{4(g)}$ is $2 \times 10^{-40} \text{ mol}^{-1} \text{ dm}^3$ at 298 K. If the equilibrium concentration of NO_2 is $2 \times 10^{-2} \text{ M}$, the concentration of N_2O_4 is
 - $6 \times 10^{-42} \text{ M}$
 - $12 \times 10^{-44} \text{ M}$
 - $8 \times 10^{-44} \text{ M}$
 - $2 \times 10^{-44} \text{ M}$
 - $4 \times 10^{-44} \text{ M}$

(2024)
- The magnitude of equilibrium constant for the gaseous reaction of $\text{H}_{2(g)}$ with $\text{I}_{2(g)}$ for the formation of $2\text{HI}_{(g)}$ is 57 at a particular temperature. The molar concentrations, $[\text{H}_2] = 0.10 \text{ M}$, $[\text{I}_2] = 0.20 \text{ M}$ and $[\text{HI}] = 0.40 \text{ M}$ are found to be at the same temperature. Find the correct statement about the reaction.
 - The mixture of $\text{H}_{2(g)}$, $\text{I}_{2(g)}$ and $\text{HI}_{(g)}$ is at equilibrium.
 - More $\text{H}_{2(g)}$ and $\text{I}_{2(g)}$ will not react to form more $\text{HI}_{(g)}$.

- (c) The concentration of $\text{H}_{2(g)}$ and $\text{I}_{2(g)}$ will decrease till the equilibrium constant is equal to reaction quotient.
- (d) Reaction quotient is independent of concentration.
- (e) If reaction quotient is greater than equilibrium constant of the reaction, more $\text{HI}_{(g)}$ will be formed. (2023)
11. The $\text{p}K_a$ of acetic acid is 4.76. What will be the $\text{p}K_b$ of ammonium hydroxide, if the pH of ammonium acetate is 7.00?
- (a) 4.770 (b) 4.765 (c) 4.755 (d) 4.750
(e) 4.740 (2023)
12. Some of the reactions and their equilibrium constants K_c are given. Choose the reaction which proceeds rarely at the given temperature.
- (a) $2\text{H}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{H}_2\text{O}_{(g)}$;
 $K_c = 2.4 \times 10^{47}$ at 500 K
- (b) $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$; $K_c = 57.0$ at 700 K
- (c) $\text{H}_{2(g)} + \text{Cl}_{2(g)} \rightleftharpoons 2\text{HCl}_{(g)}$;
 $K_c = 4.0 \times 10^{31}$ at 300 K
- (d) $\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)}$;
 $K_c = 4.8 \times 10^{-31}$ at 298 K
- (e) $\text{H}_{2(g)} + \text{Br}_{2(g)} \rightleftharpoons 2\text{HBr}_{(g)}$;
 $K_c = 5.4 \times 10^{18}$ at 300 K (2022)
13. The equilibrium constants for the following two reactions at 298 K are given below:
- $2\text{A} \rightleftharpoons \text{B} + \text{C}$; $K_1 = 16$
 $2\text{B} + \text{C} \rightleftharpoons 2\text{X}$; $K_2 = 25$
 What is the value of K for the reaction,
 $\text{A} + \frac{1}{2}\text{B} \rightleftharpoons \text{X}$ at 298 K?
- (a) $\frac{1}{5}$ (b) $\frac{1}{40}$ (c) $\frac{5}{4}$ (d) $\frac{4}{5}$
(e) 20 (2022)
14. The following concentrations were obtained for the formation of $\text{NH}_{3(g)}$ from $\text{N}_{2(g)}$ and $\text{H}_{2(g)}$ at equilibrium and at 500 K: $[\text{N}_2] = 1 \times 10^{-2}$ M, $[\text{H}_2] = 2 \times 10^{-2}$ M and $[\text{NH}_3] = 2 \times 10^{-2}$ M. The equilibrium constant, K_c , for the reaction
 $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$ at 500 K is
- (a) $5 \times 10^3 \text{ mol}^{-2} \text{ dm}^6$ (b) $1 \times 10^3 \text{ mol}^{-2} \text{ dm}^6$
(c) $5 \times 10^{-3} \text{ mol}^{-2} \text{ dm}^6$ (d) $2 \times 10^3 \text{ mol}^{-2} \text{ dm}^6$
(e) $2 \times 10^{-3} \text{ mol}^{-2} \text{ dm}^6$ (2021)
15. In which one of the following equilibria Δn_g value is zero?
- (a) $2\text{NOCl}_{(g)} \rightleftharpoons 2\text{NO}_{(g)} + \text{Cl}_{2(g)}$
(b) $\text{Ni}_{(s)} + 4\text{CO}_{(g)} \rightleftharpoons \text{Ni}(\text{CO})_{4(g)}$
(c) $\text{CO}_{2(g)} + \text{C}_{(s)} \rightleftharpoons 2\text{CO}_{(g)}$
(d) $\text{H}_{2(g)} + \text{Br}_{2(g)} \rightleftharpoons 2\text{HBr}_{(g)}$
(e) $\text{N}_2\text{O}_{4(g)} \rightleftharpoons 2\text{NO}_{2(g)}$ (2021)
16. The equilibrium constant for the equilibrium $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$ at a particular temperature is $2 \times 10^{-2} \text{ mol dm}^{-3}$. The number of moles of PCl_5 that must be taken in a one-litre flask at the same temperature to obtain a concentration of 0.20 mol of chlorine at equilibrium is
- (a) 2.0 (b) 2.2 (c) 1.8 (d) 0.2
(e) 0.1 (2020, 2015)
17. The pH of the resultant solution obtained by mixing 20 mL of 0.01 M HCl and 20 mL of 0.005 M $\text{Ca}(\text{OH})_2$ is
- (a) 2 (b) 0 (c) 1 (d) 7
(e) 5 (2020)
18. At a certain temperature, 2 moles of CO and 4 moles of Cl_2 gases were reacted to form COCl_2 in a 10 L vessel. At equilibrium if one mole of CO is present then equilibrium constant for the reaction is
- (a) 4 (b) 3.3 (c) 1 (d) 2.5
(e) 4.5 (2019)
19. The equilibrium constant for the reaction, $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$ and $2\text{N}_{2(g)} + 6\text{H}_{2(g)} \rightleftharpoons 4\text{NH}_{3(g)}$ are K_1 and K_2 , respectively. The relationship between K_1 and K_2 is
- (a) $K_2 = K_1^2$ (b) $K_2 = K_1^{-2}$
(c) $K_1 = K_2^2$ (d) $K_2 = \sqrt{K_1}$
(e) $K_1 = \sqrt{K_2}$ (2019)
20. Consider the equilibrium, $\text{X}_2 + \text{Y}_2 \rightleftharpoons ? P$. Find the stoichiometric coefficient of the P using the data given in the following table.
- | $\text{X}_2/\text{mol L}^{-1}$ | $\text{Y}_2/\text{mol L}^{-1}$ | $P/\text{mol L}^{-1}$ |
|--------------------------------|--------------------------------|-----------------------|
| 1.14×10^{-2} | 0.12×10^{-2} | 2.52×10^{-2} |
| 0.92×10^{-2} | 0.22×10^{-2} | 3.08×10^{-2} |
- (a) 1 (b) 2 (c) 3 (d) 0.5
(e) 4 (2018)
21. For the process, $\frac{3}{2}\text{A} \rightarrow \text{B}$, at 298 K, ΔG° is 163 kJ mol^{-1} . The composition of the reaction mixture is $[\text{B}] = 1$ and $[\text{A}] = 10000$. Predict the direction of the reaction and the relation between reaction quotient (Q) and the equilibrium constant (K).
- (a) Forward direction because $Q > K$
(b) Reverse direction because $Q > K$
(c) Forward direction because $Q < K$
(d) Reverse direction because $Q < K$
(e) It is at equilibrium as $Q = K$ (2017)
22. Solubility product (K_{sp}) of saturated PbCl_2 in water is $1.8 \times 10^{-4} \text{ mol}^3 \text{ dm}^{-9}$. What is the concentration of Pb^{2+} in the solution?

- (a) $(0.45 \times 10^{-4})^{1/3} \text{ mol dm}^{-3}$
 (b) $(1.8 \times 10^{-4})^{1/3} \text{ mol dm}^{-3}$
 (c) $(0.9 \times 10^{-4})^{1/3} \text{ mol dm}^{-3}$
 (d) $(2.0 \times 10^{-4})^{1/3} \text{ mol dm}^{-3}$
 (e) $(2.45 \times 10^{-4})^{1/3} \text{ mol dm}^{-3}$ (2017)
23. The correct descending order of the heat liberated (in kJ) during the neutralisation of the acids CH_3COOH (W), HF (X), HCOOH (Y) and HCN (Z) under identical conditions (K_a of $\text{CH}_3\text{COOH} = 1.8 \times 10^{-5}$, $\text{HCOOH} = 1.8 \times 10^{-4}$, $\text{HCN} = 4.9 \times 10^{-10}$ and $\text{HF} = 3.2 \times 10^{-4}$) is
 (a) $Y > X > Z > W$ (b) $X > Y > W > Z$
 (c) $W > X > Y > Z$ (d) $Z > W > Y > X$
 (e) $Z > Y > X > W$ (2016)
24. How many times a 0.1 M strong monobasic acid solution should be diluted so that pH of the resulting solution is tripled?
 (a) 50 (b) 10
 (c) 25 (d) 100
 (e) 1000 (2016)
25. The equilibrium pressure for the reaction $\text{MSO}_4 \cdot 2\text{H}_2\text{O}_{(s)} \rightleftharpoons \text{MSO}_{4(s)} + 2\text{H}_2\text{O}_{(g)}$ is $\pi/4$ atm at 400 K. The K_p for the given reaction (in atm^2) is
 (a) $\pi^2/4$ (b) $\pi/6$ (c) $\pi^2/16$ (d) $\pi/16$
 (e) $16/\pi$ (2016)
26. If the ionic product of $M(\text{OH})_2$ is 5×10^{-10} , then the molar solubility of $M(\text{OH})_2$ in 0.1 M NaOH is
 (a) $5 \times 10^{-12} \text{ M}$ (b) $5 \times 10^{-8} \text{ M}$
 (c) $5 \times 10^{-10} \text{ M}$ (d) $5 \times 10^{-9} \text{ M}$
 (e) $5 \times 10^{-16} \text{ M}$ (2015)
27. Equilibrium constants are given for the following two equilibria :
 (i) $\text{A}_{2(g)} + \text{B}_{2(g)} \rightleftharpoons 2\text{AB}_{(g)}$; $K = 2 \times 10^{-4}$
 (ii) $2\text{AB}_{(g)} + \text{C}_{2(g)} \rightleftharpoons 2\text{ABC}_{(g)}$; $K = 2 \times 10^{-2} \text{ L mol}^{-1}$
 Calculate the equilibrium constant for the following equilibrium :
 $\text{ABC}_{(g)} \rightleftharpoons 1/2\text{A}_{2(g)} + 1/2\text{B}_{2(g)} + 1/2\text{C}_{2(g)}$
 (a) $500 \text{ mol}^{1/2} \text{ L}^{1/2}$ (b) $4 \times 10^{-6} \text{ mol}^{1/2} \text{ L}^{1/2}$
 (c) $500 \text{ mol}^{-1/2} \text{ L}^{1/2}$ (d) $200 \text{ mol}^{1/2} \text{ L}^{-1/2}$
 (e) $500 \text{ mol}^{1/2} \text{ L}^{-1/2}$ (2015)

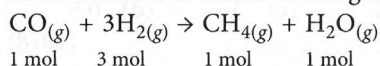
Answer Keys

1. (d) 2. (d) 3. (e) 4. (b) 5. (e) 6. (d) 7. (e) 8. (c) 9. (c) 10. (c)
 11. (d) 12. (d) 13. (e) 14. (a) 15. (d) 16. (b) 17. (d) 18. (b) 19. (a,e) 20. (b)
 21. (b) 22. (a) 23. (b) 24. (d) 25. (c) 26. (b) 27. (e)

Hints & Explanations

1. (d): Mixture of weak acid and salt of the weak acid and strong base acts as buffer. Thus, a mixture of acetic acid and sodium acetate acts as an acidic buffer solution with a pH of 4.75.

2. (d): High pressure favours the direction in which lesser number of moles of the gas are produced.

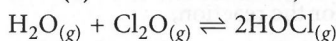


3. (e): When $\Delta n_g = 0$, then $K_p = K_c$
 where, $\Delta n_g = (\text{number of moles of gaseous products} - \text{number of moles of gaseous reactants})$

4. (b): $\text{pH} = 3 \Rightarrow [\text{H}^+] = 10^{-3}$
 $\text{pH} = 4 \Rightarrow [\text{H}^+] = 10^{-4}$
 $\text{pH} = 5 \Rightarrow [\text{H}^+] = 10^{-5}$

$$\begin{aligned} \text{For the mixture, } [\text{H}^+] &= \frac{10^{-3} + 10^{-4} + 10^{-5}}{3} \\ &= \frac{10^{-5} (100 + 10 + 1)}{3} \\ &= \frac{10^{-5} \times 111}{3} \\ &= 37 \times 10^{-5} = 3.7 \times 10^{-4} \text{ M} \end{aligned}$$

5. (e): For the reaction,



$$K_p = \frac{(P_{\text{HOCl}})^2}{P_{\text{H}_2\text{O}} \times P_{\text{Cl}_2\text{O}}} = \frac{(60)^2}{300 \times 20} = 0.60$$

Note: The value of K_p for the reaction at 400 K instead of 300 K.

6. (d): For reaction $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$
 Given $[\text{PCl}_3] = 4.0 \text{ M}$; $[\text{Cl}_2] = 4.0 \text{ M}$; $[\text{PCl}_5] = 2 \text{ M}$

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{4 \times 4}{2} = 8 \text{ M}$$

7. (e): $\text{NO}_{2(g)} + \text{SO}_{2(g)} \rightleftharpoons \text{SO}_{3(g)} + \text{NO}_{(g)}$
2 moles 2 moles

Number of moles are equal on both side hence the equilibrium will not shift.

Note: In question option (c) should be

$\text{CO}_{(g)} + 3\text{H}_{2(g)} \rightleftharpoons \text{CH}_{4(g)} + \text{H}_2\text{O}_{(g)}$ and option (e) should be $\text{NO}_{2(g)} + \text{SO}_{2(g)} \rightleftharpoons \text{SO}_{3(g)} + \text{NO}_{(g)}$

Stronger the acid, higher is the heat liberated during the neutralisation as lesser energy is used for ionisation.

∴ The correct order of heat liberated is

$X > Y > W > Z$.

24. (d): $\text{pH} = -\log [\text{H}^+]$

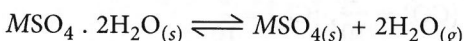
pH of 0.1 M strong monobasic acidic solution = 1

pH of the resulting solution = 3

$$\therefore [\text{H}^+] = 10^{-3} = \frac{0.1}{100}$$

So, the original solution is diluted 100 times.

25. (c): The given reaction is :



As the pressure is due to $\text{H}_2\text{O}_{(g)}$ only hence,

$$K_p = (p_{\text{H}_2\text{O}})^2 = \left(\frac{\pi}{4}\right)^2 = \frac{\pi^2}{16} \text{ atm}^2$$

26. (b): Ionic product of $M(\text{OH})_2 = [\text{M}^{2+}][\text{OH}^-]^2$

$$5 \times 10^{-10} = [\text{M}^{2+}] \times 0.1 \times 0.1$$

$$\therefore [\text{M}^{2+}] = 5 \times 10^{-8} \text{ M}$$

27. (e): $\text{A}_{2(g)} + \text{B}_{2(g)} \rightleftharpoons 2\text{AB}_{(g)}; K_1 = 2 \times 10^{-4} \dots(i)$

$2\text{AB}_{(g)} + \text{C}_{2(g)} \rightleftharpoons 2\text{ABC}_{(g)}; K_2 = 2 \times 10^{-2} \dots(ii)$

Divide equation (i) and (ii) by 2

$$\frac{1}{2} \text{A}_{2(g)} + \frac{1}{2} \text{B}_{2(g)} \rightleftharpoons \text{AB}_{(g)}; K_1 = \sqrt{2 \times 10^{-4}}$$

$$\text{AB}_{(g)} + \frac{1}{2} \text{C}_{2(g)} \rightleftharpoons \text{ABC}_{(g)}; K_2 = \sqrt{2 \times 10^{-2}}$$

Reverse the equations and add to get the final equation.

$$\text{AB}_{(g)} \rightleftharpoons \frac{1}{2} \text{A}_{2(g)} + \frac{1}{2} \text{B}_{2(g)}; K_1 = \frac{1}{\sqrt{2 \times 10^{-4}}}$$

$$\text{ABC}_{(g)} \rightleftharpoons \text{AB}_{(g)} + \frac{1}{2} \text{C}_{2(g)}; K_2 = \frac{1}{\sqrt{2 \times 10^{-2}}}$$

$$\text{ABC}_{(g)} \rightleftharpoons \frac{1}{2} \text{A}_{2(g)} + \frac{1}{2} \text{B}_{2(g)} + \frac{1}{2} \text{C}_{2(g)};$$

$$K_1 \times K_2 = \frac{1}{\sqrt{2 \times 10^{-4}}} \times \frac{1}{\sqrt{2 \times 10^{-2}}} = \frac{1}{\sqrt{4 \times 10^{-6}}} = \frac{1}{2 \times 10^{-3}} \\ = 500 \text{ mol}^{1/2} \text{ L}^{-1/2}$$



Redox Reactions and Electrochemistry

- The sum of the oxidation numbers of all the carbon and oxygen atoms in carbonate ion is
 (a) +1 (b) +2
 (c) -2 (d) -1
 (e) -3 (2024)
- What is the quantity of current required to liberate 16 g of $O_{2(g)}$ during electrolysis of water?
 (Given $1 F = 96500 C$)
 (a) $4.825 \times 10^4 C$ (b) $9.65 \times 10^4 C$
 (c) $2.895 \times 10^5 C$ (d) $4.825 \times 10^5 C$
 (e) $1.93 \times 10^5 C$ (2024)
- Which of the following statement is true with regard to Daniell cell?
 (a) Oxidation occurs at cathode
 (b) Reduction occurs at anode
 (c) E° cell is 1.1 V
 (d) Electrical energy produces chemical reaction
 (e) Electrolytes are aqueous solutions of $CuSO_4$ and $FeSO_4$. (2024)
- The conductivity of 0.02 mol L^{-1} KCl solution is 0.248 S m^{-1} . Its molar conductivity is
 (a) $20 \text{ S m}^2 \text{ mol}^{-1}$
 (b) $1.24 \times 10^{-3} \text{ S m}^2 \text{ mol}^{-1}$
 (c) $1.24 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$
 (d) $2.48 \times 10^{-2} \text{ S m}^2 \text{ mol}^{-1}$
 (e) $1.24 \times 10^{-2} \text{ S m}^2 \text{ mol}^{-1}$ (2024)
- The balanced ionic equation for the reaction of $K_2Cr_2O_7$ with Na_2SO_3 in an acid solution is
 (a) $Cr_2O_7^{2-}(aq) + SO_3^{2-}(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + SO_4^{2-}(aq) + 4H_2O(l)$
 (b) $Cr_2O_7^{2-}(aq) + 3SO_3^{2-}(aq) + 2H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$
 (c) $3Cr_2O_7^{2-}(aq) + 3SO_3^{2-}(aq) + 8H^+(aq) \rightarrow 6Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$
 (d) $3Cr_2O_7^{2-}(aq) + 3SO_3^{2-}(aq) + 2H^+(aq) \rightarrow 3Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$
 (e) $Cr_2O_7^{2-}(aq) + 3SO_3^{2-}(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + 4H_2O(l)$ (2024)
- The limiting molar conductances of NaCl, HCl and CH_3COONa at 300 K are 126.4, 425.9 and $91.0 \text{ S cm}^2 \text{ mol}^{-1}$ respectively. The limiting molar conductance of acetic acid at 300 K is
 (a) $266 \text{ S cm}^2 \text{ mol}^{-1}$
 (b) $390.5 \text{ S cm}^2 \text{ mol}^{-1}$
 (c) $461.3 \text{ S cm}^2 \text{ mol}^{-1}$
 (d) $208 \text{ S cm}^2 \text{ mol}^{-1}$
 (e) $108 \text{ S cm}^2 \text{ mol}^{-1}$ (2024)
- Which of the following material acts as a semiconductor at 298 K?
 (a) Iron (b) Copper oxide
 (c) Sodium (d) Graphite
 (e) Glass (2024)
- The resistance of a conductivity cell filled with 0.02 M KCl solution is 520 ohm at 298 K. The conductivity of the solution at 298 K is (Cell constant = 130 cm^{-1})
 (a) 0.50 S cm^{-1} (b) 1.25 S cm^{-1}
 (c) 0.025 S cm^{-1} (d) 0.25 S cm^{-1}
 (e) 0.75 S cm^{-1} (2024)
- Which of the following is used as anode in mercury cell?
 (a) Paste of NH_4Cl and $ZnCl_2$
 (b) Manganese dioxide and carbon
 (c) Paste of HgO and carbon
 (d) Paste of KOH and ZnO
 (e) Zinc-Mercury amalgam (2024)
- The quantity of electricity required to produce 18 g of Al from molten Al_2O_3 is (Atomic mass of Al = 27)
 (a) 2 F (b) 4 F (c) 5 F (d) 6 F
 (e) 1.5 F (2024)
- The average oxidation state of sulphur in the tetrathionate ion is
 (a) +3 (b) +2.5 (c) +5 (d) +3.5
 (e) +1.5 (2024)
- Calculate the log of equilibrium constant ($\log K_c$) in reaction, $Mg_{(s)} + 2Ag^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2Ag_{(s)}$
 Given that $E^\circ_{\text{cell}} = 3.245 \text{ V}$
 (a) 100.5 (b) 110.5 (c) 10 (d) 100
 (e) 110 (2023)
- The resistance of the cell containing the aqueous solution of NaCl at 20°C is 60 ohm. If the specific conductivity of this solution at 20°C is $0.04 \text{ ohm}^{-1} \text{ cm}^{-1}$, what is the cell constant in cm^{-1} ?

- (a) 2.0 (b) 1.5 (c) 0.5 (d) 0.15
(e) 2.4 (2023)
14. The average oxidation number of bromine in Br_3O_8 is
(a) $\frac{16}{3}$ (b) $\frac{4}{3}$ (c) $\frac{3}{4}$ (d) $\frac{5}{2}$
(e) $\frac{8}{3}$ (2022)
15. The standard electrode potentials of some electrodes are given below:
 $\text{Fe}^{3+}/\text{Fe}^{2+}$ 0.77 V; Br_2/Br^- 1.09 V;
 I_2/I^- 0.54 V; $\text{Zn}^{2+}/\text{Zn}_{(s)}$ -0.76 V;
 $\text{Ag}^+/\text{Ag}_{(s)}$ 0.80 V; $\text{Fe}^{2+}/\text{Fe}_{(s)}$ -0.44 V;
 $\text{Cu}^{2+}/\text{Cu}_{(s)}$ 0.34 V
 Predict the reaction that is not feasible.
 (a) $\text{Fe}_{(aq)}^{3+}$ oxidises $\text{I}_{(aq)}^-$
 (b) $\text{Ag}_{(aq)}^+$ oxidises $\text{Cu}_{(s)}$
 (c) $\text{Ag}_{(s)}$ reduces $\text{Fe}_{(aq)}^{3+}$
 (d) $\text{Br}_{2(aq)}$ oxidises $\text{Fe}_{(aq)}^{2+}$
 (e) $\text{Zn}_{(s)}$ reduces $\text{Cu}_{(aq)}^{2+}$ (2022)
16. Which of the following is an example of disproportionation redox reaction?
 (a) $\text{N}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{NO}_{(g)}$
 (b) $2\text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{H}_2\text{O}_{(l)}$
 (c) $2\text{Pb}(\text{NO}_3)_{2(s)} \rightarrow 2\text{PbO}_{(s)} + 4\text{NO}_{2(g)} + \text{O}_{2(g)}$
 (d) $\text{NaH}_{(s)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{NaOH}_{(aq)} + \text{H}_{2(g)}$
 (e) $2\text{NO}_{2(g)} + 2\text{OH}^- \rightarrow \text{NO}_{2(aq)}^- + \text{NO}_{3(aq)}^- + \text{H}_2\text{O}_{(l)}$ (2021)
17. The SI unit of molar conductivity is
 (a) $\text{S m}^3 \text{mol}^{-1}$ (b) S m mol^{-1}
 (c) S m mol^{-2} (d) $\text{S m}^2 \text{mol}^{-1}$
 (e) $\text{S m}^2 \text{mol}^{-2}$ (2021)
18. $\text{CH}_4(g) + 4\text{Cl}_{2(g)} \rightarrow \text{CCl}_{4(l)} + 4\text{HCl}_{(g)}$
 In the above reaction, the change of oxidation state of carbon is
 (a) from +4 to -4 (b) from +1 to +4
 (c) from -4 to +4 (d) from -1 to +1
 (e) from -4 to -1 (2020)
19. How many moles of platinum will be deposited on cathode when 0.40 F of electricity is passed through a 1.0 M solution Pt^{4+} ?
 (a) 0.60 mol (b) 1.0 mol
 (c) 0.40 mol (d) 0.45 mol
 (e) 0.10 mol (2020)
20. E_{cell} of the following cell is
 $\text{Pt}_{(s)} | \text{H}_{2(g)}, 1 \text{ bar} | \text{H}^+ (1 \text{ M}) || \text{H}^+ (0.1 \text{ M}) | \text{H}_{2(g)}, 1 \text{ bar} | \text{Pt}_{(s)}$
 (a) $-\frac{2.303RT}{F}$ (b) $\frac{2.303RT}{F}$
 (c) $-\frac{2.303RT}{2F}$ (d) $\frac{2.303RT}{2F}$
- (e) $\frac{RT}{2F}$ (2019)
21. In a lead-acid battery, if 1 A current is passed to charge the battery for 1 h, what is the amount of PbSO_4 converted to PbO_2 ? (Given data: $1 \text{ F} = 96500 \text{ C mol}^{-1}$)
 (a) 0.0373 moles (b) 0.0186 moles
 (c) 0.0093 moles (d) 0.0268 moles
 (e) 0.0400 moles (2019)
22. A fuel cell operates at constant current with H_2 fuel (1 bar) and O_2 oxidant (1 bar). The electrolyte used is 0.001 M HCl and the product(s) of the reaction are confined inside the fuel cell. Which of the following is true about the electrolyte?
 (a) Boiling point of the electrolyte decreases with increase in the duration of fuel cell operation.
 (b) Boiling point of the electrolyte increases with increase in the duration of fuel cell operation.
 (c) Open circuit voltage of the fuel cell remains constant with increase in duration of operation.
 (d) Open circuit voltage of the fuel cell increases with increase in duration of operation.
 (e) Both (a) and (c). (2019)
23. The voltage of the cell consisting of $\text{Li}_{(s)}$ and $\text{F}_{2(g)}$ electrodes is 5.92 V at standard condition at 298 K. What is the voltage if the electrolyte consists of 2 M LiF ($\ln 2 = 0.693$, $R = 8.314 \text{ J K}^{-1} \text{mol}^{-1}$ and $F = 96500 \text{ C mol}^{-1}$)?
 (a) 5.90 V (b) 5.937 V
 (c) 5.88 V (d) 4.9 V
 (e) 4.8 V (2018)
24. Consider the galvanic cell,
 $\text{Pt}_{(s)} | \text{H}_2 (1 \text{ bar}) | \text{HCl}_{(aq)} (1 \text{ M}) | \text{Cl} (1 \text{ bar}) | \text{Pt}_{(s)}$.
 After running the cell for sometime, the concentration of the electrolyte is automatically raised to 3 M HCl. Molar conductivity of the 3 M HCl is about $240 \text{ S cm}^2 \text{mol}^{-1}$ and limiting molar conductivity of HCl is about $420 \text{ S cm}^2 \text{mol}^{-1}$. If K_b of water is $0.52 \text{ K kg mol}^{-1}$, calculate the boiling point of the electrolyte at the end of the experiment.
 (a) 375.6 K (b) 376.3 K
 (c) 378.1 K (d) 380.3 K
 (e) 381.6 K (2018)
25. 1 mole of FeSO_4 (atomic weight of Fe is 55.84 g mol^{-1}) is oxidized to $\text{Fe}_2(\text{SO}_4)_3$. Calculate the equivalent weight of ferrous ion.
 (a) 55.84 (b) 27.92
 (c) 18.61 (d) 111.68
 (e) 83.76 (2018)
26. Calculate the molarity of a solution containing 5 g of NaOH dissolved in the product of a $\text{H}_2 - \text{O}_2$ fuel

- cell operated at 1 A current for 595.1 hours. (Assume $1F = 96500 \text{ C/mol}$ of electrons and molecular weight of NaOH as 40 g mol^{-1})
- (a) 0.05 M (b) 0.025 M
(c) 0.1 M (d) 0.075 M
(e) 1 M (2018)
27. Consider the electrochemical reaction between $\text{Ag}_{(s)}$ and $\text{Cl}_{2(g)}$ electrodes in 1 litre of 0.1 M KCl aqueous solution. Solubility product of AgCl is 1.8×10^{-10} and $F = 96500 \text{ C/mol}$. At $1 \mu\text{A}$ current, calculate the time required to start observing the AgCl precipitation in the galvanic cell.
- (a) 173 s (b) 346 s
(c) $1.25 \times 10^6 \text{ s}$ (d) $1.25 \times 10^5 \text{ s}$
(e) 101 s (2018)
28. Consider a fuel cell supplied with 1 mole of H_2 gas and 10 moles of O_2 gas. If fuel cell is operated at 96.5 mA current, how long will it deliver power? (Assume $1F = 96500 \text{ C/mole of electrons}$)
- (a) $1 \times 10^6 \text{ s}$ (b) $0.5 \times 10^6 \text{ s}$
(c) $2 \times 10^6 \text{ s}$ (d) $4 \times 10^6 \text{ s}$
(e) $5 \times 10^6 \text{ s}$ (2017)
29. Consider the equilibrium obtained by electrically connecting zinc-amalgam (Zn(Hg)) and HgO electrodes in mercury cell,
 $\text{Zn(Hg)} + \text{HgO}_{(s)} \rightleftharpoons \text{ZnO}_{(s)} + \text{Hg}_{(l)}$
 Under this equilibrium what is the relation between the potential of the Zn(Hg) and HgO electrodes measured against the standard hydrogen electrode?
- (a) Zn(Hg) electrode potential is equal to HgO electrode potential.
(b) Zn(Hg) electrode potential is more than HgO electrode potential.
- (c) HgO electrode potential is more than Zn(Hg) electrode.
(d) Cell voltage at above said equilibrium is 1.35 V.
(e) Both (c) and (d). (2017)
30. The standard reduction potential for Zn^{2+}/Zn , Ni^{2+}/Ni and Fe^{2+}/Fe are -0.76 , -0.23 and -0.44 V respectively. The reaction, $\text{X} + \text{Y}^{2+} \longrightarrow \text{X}^{2+} + \text{Y}$ will have more negative ΔG value when X and Y are
- (a) $\text{X} = \text{Ni}$; $\text{Y} = \text{Fe}$ (b) $\text{X} = \text{Ni}$; $\text{Y} = \text{Zn}$
(c) $\text{X} = \text{Fe}$; $\text{Y} = \text{Zn}$ (d) $\text{X} = \text{Zn}$; $\text{Y} = \text{Ni}$
(e) $\text{X} = \text{Fe}$; $\text{Y} = \text{Ni}$ (2016)
31. One mole of hydrazine (N_2H_4) loses 10 moles of electrons in a reaction to form a new compound X. Assuming that all the nitrogen atoms in hydrazine appear in the new compound, what is the oxidation state of nitrogen in X?
 (Note : There is no change in the oxidation state of hydrogen in the reaction.)
- (a) -1 (b) -3 (c) $+3$ (d) $+5$
(e) $+1$ (2016)
32. How many moles of platinum will be deposited on the cathode when 0.60 F of electricity is passed through a 1.0 M solution of Pt^{4+} ?
- (a) 0.60 mol (b) 0.15 mol
(c) 0.30 mol (d) 0.45 mol
(e) 1.0 mol (2015)
33. The standard electrode potentials of Zn and Ni are respectively -0.76 V and -0.25 V . Then the standard emf of the spontaneous cell by coupling these under standard conditions is
- (a) $+1.01 \text{ V}$ (b) -0.51 V
(c) $+0.82 \text{ V}$ (d) $+0.25 \text{ V}$
(e) $+0.51 \text{ V}$ (2015)

Answer Keys

1. (c) 2. (e) 3. (c) 4. (e) 5. (e) 6. (b) 7. (b) 8. (d) 9. (e) 10. (a)
 11. (b) 12. (e) 13. (e) 14. (a) 15. (c) 16. (e) 17. (d) 18. (c) 19. (e) 20. (a)
 21. (b) 22. (a) 23. (a) 24. (a) 25. (a) 26. (None) 27. (a) 28. (c) 29. (a) 30. (d)
 31. (c) 32. (b) 33. (e)

Hints & Explanations

1. (c) : In polyatomic ion, the algebraic sum of all the oxidation numbers of atoms of the ion must equal the charge on the ion. Thus, the sum of oxidation number of three oxygen atoms and one carbon atom in the carbonate ion, CO_3^{2-} must equal to -2 .

2. (e) : $2\text{H}_2\text{O}_{(l)} \longrightarrow \text{O}_{2(g)} + 4\text{H}^+_{(aq)} + 4\text{e}^-$
 Quantity of current required to liberate 32 g $\text{O}_{2(g)}$ during electrolysis of water = $4F = 4 \times 96500 \text{ C}$

$\therefore$ Quantity of current required to liberate 16 g $\text{O}_{2(g)}$

$$\text{During electrolysis of water} = \frac{4 \times 96500 \times 16}{32} \\ = 1.93 \times 10^5 \text{ C}$$

3. (c) : Daniell cell is electrochemical cell, in which chemical energy released by redox reaction converts into electrical energy
 $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$

Anode $\rightarrow$ Zn electrode – oxidation takes place.

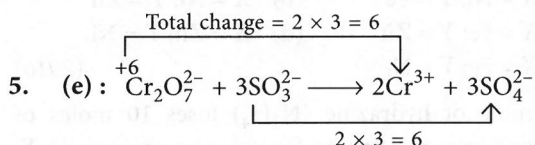
Cathode $\rightarrow$ Cu electrode – reduction takes place.

Electrolyte used are : ZnSO_4 and CuSO_4

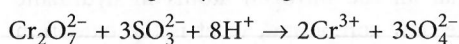
$$E^\circ_{\text{cell}} = 1.1 \text{ V}$$

4. (e) : Given : $K = 0.248 \text{ s m}^{-1}$; $C = 0.02 \text{ mol}^{-1}$

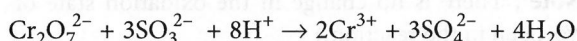
$$\Lambda^\circ_m = \frac{K}{C \times 1000} = \frac{0.248}{0.02 \times 1000} = 1.24 \times 10^{-2} \text{ S m}^2 \text{ mol}^{-1}$$



Balance charges by adding H^+



Balance H by adding H_2O .



6. (b) : Given $\Lambda^\circ_{\text{NaCl}} = 126.4 \text{ S cm}^2 \text{ mol}^{-1}$,

$$\Lambda^\circ_{\text{HCl}} = 425.9 \text{ S cm}^2 \text{ mol}^{-1},$$

$$\Lambda^\circ_{\text{CH}_3\text{COONa}} = 91.0 \text{ S cm}^2 \text{ mol}^{-1},$$

$$\Lambda^\circ_{\text{CH}_3\text{COOH}} = (\Lambda^\circ_{\text{CH}_3\text{COONa}} + \Lambda^\circ_{\text{HCl}}) - \Lambda^\circ_{\text{NaCl}}$$

$$= (91.0 + 425.9) - (126.4)$$

$$= 516.9 - 126.4 = 390.5 \text{ S cm}^2 \text{ mol}^{-1}$$

7. (b) : Copper oxide act as semiconductor at 298 K.

8. (d) : Given : Resistance (R) = 520 ohm

$$\text{Cell constant } (G^*) = 130 \text{ cm}^{-1}$$

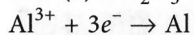
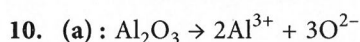
$$G^* = R\kappa$$

$$\kappa = \frac{G^*}{R} = \frac{130}{520} = \frac{1}{4} = 0.25 \text{ S cm}^{-1}$$

9. (e) : Mercury cell : Anode : Zinc-Mercury amalgam

Cathode : HgO mixed with carbon.

Electrolyte : Paste of KOH and ZnO .



Molar mass = 27 g/mol

1 mole of e^- = 1 F

27 g of Al requires $\rightarrow$ 3 F electricity

18 g of Al requires $\rightarrow \frac{3}{27} \times 18 = 2 \text{ F electricity}$

11. (b) : Tetrathionate ion = $\text{S}_4\text{O}_6^{2-}$

$$4x + (-2 \times 6) = -2$$

$$x = \frac{-2 + 12}{4} = \frac{10}{4} = 2.5$$

$$12. \text{ (e) : } E^\circ_{\text{cell}} = \frac{0.059}{2} \log K_c$$

$$\text{or, } \log K_c = \frac{2 \times E^\circ_{\text{cell}}}{0.059} = \frac{2 \times 3.245}{0.059} = 110$$

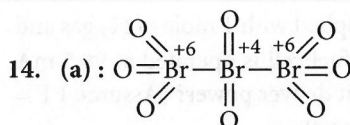
$$13. \text{ (e) : } R = \rho \frac{l}{a}$$

$$R = \rho \times \text{cell constant}$$

$$\frac{1}{R} = \frac{1}{\rho} \times \frac{1}{\text{cell constant}} = \kappa \times \frac{1}{\text{cell constant}}$$

$$\text{Cell constant} = \kappa \times R \left[\frac{1}{\rho} = \kappa = \text{specific conductivity} \right]$$

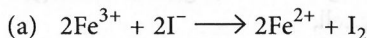
$$= 0.04 \text{ ohm}^{-1} \text{ cm}^{-1} \times 60 \text{ ohm} = 2.4 \text{ cm}^{-1}$$



$$\text{Average oxidation state} = \frac{16}{3}$$

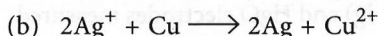
15. (c) : A reaction is feasible if EMF of cell is +ve.

Cathode : At which reduction occurs, Anode : At which oxidation occurs.

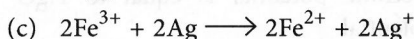


$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.77 - 0.54$$

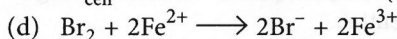
$$= 0.23 \text{ V (feasible)}$$



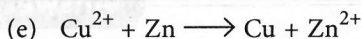
$$E^\circ_{\text{cell}} = 0.80 - 0.34 = 0.46 \text{ V (feasible)}$$



$$E^\circ_{\text{cell}} = 0.77 - 0.80 = -0.03 \text{ V (non-feasible)}$$

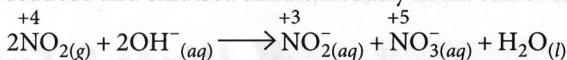


$$E^\circ_{\text{cell}} = 1.09 - 0.77 = 0.32 \text{ V (feasible)}$$



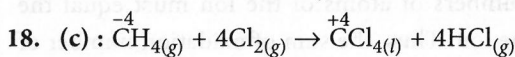
$$E^\circ_{\text{cell}} = 0.34 - (-0.76) = 1.1 \text{ V (feasible)}$$

16. (e) : In disproportionation reactions, an element gets reduced and oxidised simultaneously in the same reaction.



$$17. \text{ (d) : } \Lambda_m = \frac{\kappa \times 1000}{\text{Molarity}}$$

SI unit of molar conductivity is $\text{S m}^2 \text{ mol}^{-1}$.



In the given reaction, oxidation state of carbon changes from -4 to $+4$.

19. (e) : We have the reaction, $\text{Pt}^{4+} + 4e^- \longrightarrow \text{Pt}$

According to given reaction, 4 F electricity is required to deposit 1 mole of Pt.

$\Rightarrow$ 0.40 F electricity will deposit $= \frac{1}{4} \times 0.40 = 0.10$ mol

$$20. (a): E_{\text{cell}} = \frac{2.303RT}{nF} \log \frac{C_2}{C_1}$$

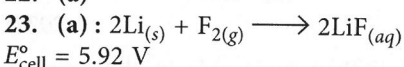
$$= \frac{2.303RT}{1F} \log \frac{0.1}{1} = \frac{-2.303RT}{F}$$

21. (b): $I = 1$ A, $t = 1$ hr $= 3600$ s
 $w = ZIt$

$$w = \frac{\text{eq. wt.}}{96500} \times 1 \times 3600; \quad \frac{w}{\text{eq. wt.}} = \frac{3600}{96500} \text{ g. eq.}$$

$$\text{mole} = \text{g. eq.} / 2 = \frac{3600}{96500 \times 2} = 0.0186 \text{ moles}$$

22. (a)



$$E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{0.0591}{2} \log [\text{LiF}]^2$$

$$E_{\text{cell}}^\circ = 5.92 - \frac{0.059}{2} \log 2^2$$

$$= 5.92 - 0.059 \times 0.3010 = 5.90$$

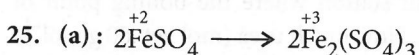
24. (a): $\alpha = \frac{\text{Molar conductivity}}{\text{Limiting molar conductivity}}$

$$= \frac{240}{420} = \frac{12}{21}$$

$$\alpha = \frac{i-1}{n-1} = \frac{i-1}{2-1} = \frac{12}{21}; \quad i = \frac{12}{21} + 1 = \frac{33}{21}$$

$$\Delta T_b = iK_b m = \frac{33}{21} \times 0.52 \times 3 = 2.45 \text{ K}$$

$$T_b = T_b^\circ + \Delta T_b = 373.15 + 2.45 = 375.6 \text{ K}$$



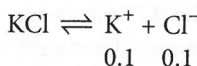
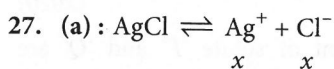
Change in oxidation state per Fe atom is 1. So, equivalent weight of ferrous ion is equal to its atomic weight.

26. (None) : Net reaction of H_2 - O_2 fuel cell:
 $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

$$w = ZIt = \frac{EIt}{96500} = \frac{9 \times 1 \times 595.1 \times 60 \times 60}{96500} = 200 \text{ g}$$

Density of water = 1 g/mL

$$M = \frac{\text{Moles of NaOH}}{200} \times 1000 = \frac{5 \times 1000}{40 \times 200} = 0.625 \text{ M}$$



...(i)

...(ii)

$$[\text{Ag}^+] = x;$$

$$[\text{Cl}^-] = x + 0.1 \quad [\because x \ll 0.1]$$

$$\therefore [\text{Cl}^-] = 0.1$$

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] \quad (\text{To just start the precipitation})$$

$$x \times 0.1 = 1.8 \times 10^{-10}$$

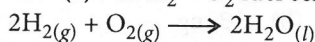
$$x = \frac{1.8 \times 10^{-10}}{0.1} = 1.8 \times 10^{-9}$$

$$\text{Mass of AgCl}(w) = 1.8 \times 10^{-9} \times 143$$

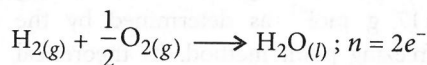
$$w = ZIt$$

$$t = \frac{w}{ZI} = \frac{1.8 \times 10^{-9} \times 143 \times 96500}{143 \times 1 \times 10^{-6}} = 173.7 \text{ s}$$

28. (c): In H_2 - O_2 fuel cell, net reaction is



Since, the cell is supplied with 1 mole of H_2 gas and 10 moles of O_2 , H_2 is the limiting reagent. Thus, 1 mole of H_2 reacts with 0.5 mole of O_2 ,

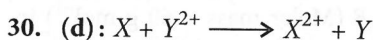


$$Q = nF \text{ and } Q = I \times t$$

$$\text{Thus, } 2 \times 96500 = 96.5 \times 10^{-3} \times t$$

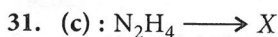
$$t = \frac{2 \times 96500}{96.5 \times 10^{-3}} = 2 \times 10^6 \text{ s}$$

29. (a)



$$\Delta G = -nFE_{\text{cell}}$$

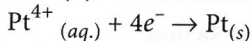
Greater the value of E_{cell} , more negative will be the value of ΔG and greater the difference between standard reduction potentials of X^{2+} and Y^{2+} , greater will be the value of E_{cell} . Hence, $X = \text{Zn}$ and $Y = \text{Ni}$



No. of electrons lost per N-atom = 5

Oxidation state of N in new compound = $-2 + 5 = +3$

32. (b): The reduction reaction is



1 mole 4 moles

One mole of Pt^{4+} requires 4 moles of electrons for reduction

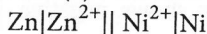
i.e., $Q = 4 \times F$

4 F of current produces 1 mole of Pt.

Hence 0.60 F of current will produce

$$\frac{1 \times 0.60}{4} = 0.15 \text{ mol of Pt}$$

33. (e): The cell is represented as:



$$E_{\text{cell}}^\circ = E_{\text{cathode}}^\circ - E_{\text{anode}}^\circ$$

$$= -0.25 - (-0.76) = -0.25 + 0.76 = 0.51 \text{ V}$$



Solutions

- What is the mass of crystalline oxalic acid (molar mass = 126 g mol^{-1}) present in 50 mL of 0.02 N aqueous oxalic acid solution?
 - 63 mg
 - 6.3 mg
 - 31.5 mg
 - 0.063 mg
 - 310 mg
 (2024)
- The observed molecular weight of 1 : 1 strong electrolyte is 117 g mol^{-1} as determined by the depression of freezing point method. Its theoretical molecular weight is 60 g mol^{-1} . The percentage of dissociation of the electrolyte is
 - 90%
 - 95%
 - 100%
 - 85%
 (2024)
- An aqueous solution contains 20 g of a non-volatile strong electrolyte A_2B (Molar mass = 60 g mol^{-1}) in 1 kg of water. If the electrolyte is 100% dissociated at this concentration, what is the boiling point of the solution? (K_b of water is $0.52 \text{ K kg mol}^{-1}$)
 - 372.482 K
 - 374.56 K
 - 373.52 K
 - 371.44 K
 (2024)
- The vapour pressure of H_2O at 323 K is 95 mm of Hg. 176 g of sucrose (Molar mass = 342 g mol^{-1}) is added to 900 g of H_2O at 323 K. The vapour pressure of solution is about
 - 93.94 mm
 - 92.88 mm
 - 96.06 mm
 - 95.33 mm
 (2024)
- 260 g of an aqueous solution contains 60 g of urea (Molar mass = 60 g mol^{-1}). The molality of the solution is
 - 2 m
 - 3 m
 - 4 m
 - 5 m
 (2024)
- Which of the following liquid pair shows negative deviation from Raoult's law?
 - Phenol – Aniline
 - Acetone – Carbon disulphide
 - Benzene – Toluene
 - n*-hexane – *n*-heptane
 - Bromoethane – Chloroethane
 (2024)
- The molarity of a solution containing 8 g of NaOH (Molar mass = 40 g mol^{-1}) in 250 mL solution is
 - 0.8 M
 - 0.4 M
 - 0.2 M
 - 0.5 M
 - 0.6 M
 (2024)
- The molarity of sodium hydroxide in the solution prepared by dissolving 6 g in 600 mL of water is (molar mass of NaOH = 40 g mol^{-1})
 - 0.5 M
 - 0.4 M
 - 0.25 M
 - 0.1 M
 - 0.2 M
 (2024)
- The volume of ethanol required to prepare 3 L of 0.25 M aqueous solution is (density of ethanol = 0.36 kg L^{-1} , molar mass = 60 g mol^{-1})
 - 125 mL
 - 25 mL
 - 75 mL
 - 50 mL
 - 12.5 mL
 (2024)
- Which of the following mixture forms azeotrope?
 - Phenol-aniline
 - Nitric acid-water
 - Ethanol-acetone
 - Chloroform-acetone
 - CS_2 -acetone
 (2024)
- A scientist wants to perform an experiment in aqueous solution in a hill station where the boiling point of water is 98.98°C . How much urea (mol. wt. 60 g mol^{-1}) is to be added by him to 2 kg of water to get the boiling point 100°C at the same place? (K_b of water = $0.51 \text{ K kg mol}^{-1}$)
 - 60 g
 - 120 g
 - 180 g
 - 240 g
 - 1.02 g
 (2021)
- A solution is prepared by dissolving 20 g NaOH in 1250 mL of a solvent of density 0.8 g/mL . Then the molality of the solution is
 - 0.2 mol kg^{-1}
 - 0.08 mol kg^{-1}
 - 0.25 mol kg^{-1}
 - $0.0064 \text{ mol kg}^{-1}$
 - 0.5 mol kg^{-1}
 (2020)
- When the same amount of solute 'P' and 'Q' are separately dissolved in 500 g water, the ΔT_f values are 0.15 K and 0.30 K respectively. If the molecular weight of 'P' is 80 g mol^{-1} , then the molecular weight of 'Q' is
 - 30 g mol^{-1}
 - 60 g mol^{-1}
 - 40 g mol^{-1}
 - 45 g mol^{-1}
 - 160 g mol^{-1}
 (2020)

14. The Henry's law constant for O_2 dissolved in water is 4.34×10^4 atm at certain temperature. If the partial pressure of O_2 in a gas mixture that is in equilibrium with water is 0.434 atm, what is the mole fraction of O_2 in the solution?
 (a) 1×10^{-5} (b) 1×10^{-4}
 (c) 2×10^{-5} (d) 1×10^{-6}
 (e) 2×10^{-6} (2019)
15. Acetic acid dimerizes when dissolved in benzene. As a result, boiling point of the solution rises by 0.36°C , when 100 g of benzene is mixed with 'X' g of acetic acid. In this solution, if experimentally measured molecular weight of acetic acid is 117.8 and molal elevation constant of benzene is $2.57 \text{ K kg mol}^{-1}$, what is the weight % and degree of dissociation (in %) of acetic acid in benzene?
 (a) 1.62 and 98.3 (b) 0.81 and 98.3
 (c) 0.5 and 86 (d) 1 and 98.3
 (e) 1.4 and 99 (2019)
16. If 1 mole of NaCl solute is dissolved into the 1 kg of water, at what temperature will water boil at 1.013 bar? (K_b of water is $0.52 \text{ K kg mol}^{-1}$).
 (a) 373.15 K (b) 373.67 K
 (c) 374.19 K (d) 373.19 K
 (e) 375 K (2018)
17. The freezing point of equimolal aqueous solutions will be highest for
 (a) $C_6H_5NH_3Cl$ (b) $AgNO_3$
 (c) $Ca(NO_3)_2$ (d) $La(NO_3)_3$
 (e) D-fructose. (2017)
18. Calculate the molality of a solution that contains 51.2 g of naphthalene, ($C_{10}H_8$), in 500 mL of carbon tetrachloride. The density of CCl_4 is 1.60 g/mL.
 (a) 0.250 m (b) 0.500 m (c) 0.750 m (d) 0.840 m
 (e) 1.69 m (2016)
19. 31 g of ethylene glycol ($C_2H_6O_2$) is mixed with 500 g of solvent (K_f of the solvent is 2 K kg mol^{-1}). What is the freezing point of the solution in K? (Freezing point of solvent = 273 K)
 (a) 272 (b) 271 (c) 270 (d) 274
 (e) 275 (2016)
20. 18 g of glucose is dissolved in 178.2 g of water. The vapour pressure of the solution at 100°C is (vapour pressure of pure water at 100°C is 760 mm Hg)
 (a) 767.6 mm Hg (b) 760 mm Hg
 (c) 752.4 mm Hg (d) 725.4 mm Hg
 (e) 745.2 mm Hg (2015)
21. Which one of the following binary liquid mixtures exhibits positive deviation from Raoult's law?
 (a) Carbon disulphide – Acetone
 (b) Chloroform – Acetone
 (c) Bromobenzene – Chlorobenzene
 (d) Benzene – Toluene
 (e) Phenol – Aniline (2015)

Answer Keys

1. (a) 2. (b) 3. (c) 4. (e) 5. (d) 6. (a) 7. (a) 8. (c) 9. (a) 10. (b)
 11. (d) 12. (e) 13. (c) 14. (a) 15. (a) 16. (c) 17. (e) 18. (b) 19. (b) 20. (c)
 21. (a)

Hints & Explanations

1. (a) : Given, Normality = 0.02 N
 Molar mass of oxalic acid = 126 g mol^{-1}
 Volume of solution (V) = 50 mL

$$\text{Normality} = \frac{\text{No. of g.eq. of solute}}{\text{Volume of solution in L (V)}}$$

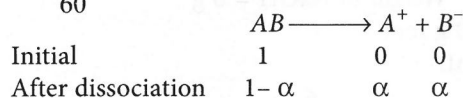
$$\text{g.eq.} = \frac{\text{Mass of solute in g (W)}}{\text{Eq. mass of solute (E)}}$$

$$\therefore \text{Normality} = \frac{W}{E \times V}$$

$$\begin{aligned} W &= E \times V \times \text{Normality} \\ &= 63 \times 0.05 \times 0.02 \\ &= 0.063 \text{ g} \\ &= 63 \text{ mg} \end{aligned}$$

2. (b) : Observed molecular weight = 117 g mol^{-1}
 Actual molar weight = 60 g mol^{-1}

$$i = \frac{117}{60} = 1.95$$



$$\begin{aligned} \text{Total moles} &= 1 - \alpha + \alpha + \alpha \\ &= 1 + \alpha \end{aligned}$$

$$\begin{aligned} i &= 1 + \alpha = 1.95 \\ \alpha &= 0.95 \end{aligned}$$

$\therefore$ Degree of dissociation = 0.95
 Percentage of dissociation = 95%

3. (c) : $A_2B \longrightarrow 2A^+ + B^{2-}$
 For 100% dissociation, $i = 3$

$$\Delta T_b = i \times K_b \times m$$

$$= 3 \times 0.52 \times \frac{20}{60 \times 1} = 0.52$$

$$\Delta T_b = T_b - T_b^\circ$$

$$T_b - T_b^\circ = 0.52$$

$$\text{or } T_b = T_b^\circ + 0.52 = 373 + 0.52 = 373.52 \text{ K}$$

4. (e): V.P. H_2O = 95 mm of Hg; Mass of H_2O = 900 g

Mass of sucrose = 176 g;

Molar mass of sucrose is 342 g mol^{-1}

$$n_{\text{sucrose}} = \frac{176}{342} = 0.515; n_{\text{H}_2\text{O}} = \frac{900}{18} = 50$$

Relative lowering of V.P.

$$= \frac{P_1^0 - P_1}{P_1^0} = \frac{n_2}{n_1 + n_2} \Rightarrow \frac{95 - P_1}{95} = \frac{0.515}{0.515 + 50}$$

$$\Rightarrow 95 - P_1 = \frac{0.515 \times 95}{50.515} = \frac{48.88}{50.515} = 0.968$$

$$P_1 = 95 - 0.968 = 94.03 \text{ mm}$$

5. (d): Given : Mass of solution = 260 g

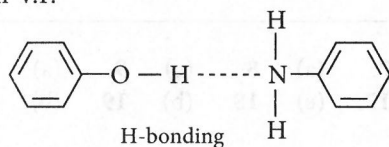
Mass of urea = 60 g

Mass of solvent = $260 - 60 = 200 \text{ g}$

Molar mass of urea = 60 g mol^{-1}

$$\begin{aligned} \text{Molality} &= \frac{\text{no. of moles of solute}}{\text{Mass of solvent (kg)}} \\ &= \frac{60/60}{200} \times 1000 = 5 \text{ m} \end{aligned}$$

6. (a): Phenol-Aniline shows negative deviation due to H-bonding, they bond with each other, that result in decrease in V.P.



7. (a): Given mass of NaOH = 8 g;

Molar mass = 40 g mol^{-1}

$$\begin{aligned} \text{Molarity} &= \frac{\text{no. of moles of solute}}{\text{Volume of solution (L)}} \\ &= \frac{8}{40} \times \frac{1000}{250} = 0.8 \text{ M} \end{aligned}$$

8. (c): Given : Weight of NaOH = 6 g

Molar mass = 40 g mol^{-1}

Volume = 600 mL

$$\text{Molarity} = \frac{\text{No. of moles}}{V(L)} = \frac{\frac{6}{40}}{\frac{600}{1000}} = 0.25 \text{ M}$$

9. (a): Given : Molar mass of ethanol = 60 g
= $0.060 \text{ kg mol}^{-1}$

Density = 0.36 kg L^{-1}

$$\text{Molarity} = \frac{\text{Density}}{\text{Molar mass}} = \frac{0.36}{0.06} = 6 \text{ mol L}^{-1}$$

Applying formula $M_1 V_1 = M_2 V_2$

$$6 \times V = 3 \times 0.25$$

$$V = \frac{3 \times 0.25}{6} = 0.125 \text{ L} = 125 \text{ mL}$$

10. (b): Mixture of nitric acid and water forms maximum boiling azeotrope. The composition of azeotropic mixture is 68% nitric acid and 32% water, it boils at nearly 395 K.

11. (d): $T_b^\circ = 98.98^\circ\text{C}$, $T_b = 100^\circ\text{C}$

$$\Delta T_b = T_b - T_b^\circ = 100 - 98.98 = 1.02^\circ\text{C} = 1.02 \text{ K}$$

$$K_b = 0.51 \text{ K kg mol}^{-1}$$

$$m = \frac{\text{Moles of Urea}}{\text{Mass of water (kg)}} = \frac{w/60}{2}$$

$$\Delta T_b = K_b m$$

$$1.02 = 0.51 \times \frac{w}{60 \times 2} \Rightarrow w = \frac{60 \times 2 \times 1.02}{0.51} = 240 \text{ g}$$

12. (e): Mass of solvent = Density $\times$ Volume

$$= 0.8 \text{ g/mL} \times 1250 \text{ mL} = 1000 \text{ g or 1 kg}$$

$$\text{Molality (M)} = \frac{\text{Moles}}{\text{Mass of solvent (kg)}} = \frac{20/40}{1} = 0.5 \text{ mol kg}^{-1}$$

$$13. (c): \text{Mass of solvent} = 500 \text{ g} \times \frac{1 \text{ kg}}{10^3 \text{ g}} = 0.5 \text{ kg}$$

As same amount of solute are dissolved in water, so, let mass of solute be x .

$$\text{Molality of P} = \frac{x/80}{0.5}; \quad \text{Molality of Q} = \frac{x/MW_{(Q)}}{0.5}$$

We know,

$$\Delta T_f = K_f m \quad (K_f \text{ will be equal for P and Q.})$$

$$K_{f(P)} = \frac{0.15 \times 0.5}{x/80}; \quad K_{f(Q)} = \frac{0.30 \times 0.5}{x/MW_{(Q)}}$$

$$\frac{0.15 \times 0.5}{x/80} = \frac{0.30 \times 0.5}{x/MW_{(Q)}}; \quad MW_{(Q)} = 40 \text{ g mol}^{-1}$$

14. (a): $K_H = 4.34 \times 10^4 \text{ atm}$

$$p_{\text{O}_2} = 0.434 \text{ atm}$$

$$p_{\text{O}_2} = K_H \times x$$

$$x = \frac{p_{\text{O}_2}}{K_H} = \frac{0.434}{4.34 \times 10^4} = 1 \times 10^{-5}$$

15. (a): $\Delta T_b = 0.36$

Mass of acetic acid = 'X' g

Mass of benzene = 100 g

Experimental molar mass = 117.8 g/mol

$$K_b = 2.57 \text{ K kg mol}^{-1}$$

$$i = \frac{\text{normal molar mass}}{\text{observed molar mass}} = \frac{60}{117.8} = 0.51$$

$$\Delta T_f = i K_b m = 0.51 \times 2.57 \times \frac{X}{60} \times \frac{1000}{100}$$

$$0.36 = 0.51 \times 2.57 \times \frac{X}{6} \Rightarrow X = \frac{6 \times 0.36}{0.51 \times 2.57} = 1.65 \text{ g}$$

Thus, % of acetic acid = 1.65 %

Degree of association

$$\alpha = \frac{1-i}{1-\frac{1}{n}} = \frac{1-0.51}{1-\frac{1}{2}} = \frac{0.49}{1/2} = 0.98 \text{ i.e., } 98\%$$

16. (c) : Molality of NaCl solution

$$= \frac{\text{Moles}}{\text{Mass of solvent (kg)}} = \frac{1}{1} = 1 \text{ m}$$

$$\Delta T_b = iK_b m = 2 \times 0.52 \times 1 = 1.04 \text{ K}$$

$$T_b = T_b^\circ + \Delta T_f = 373.15 + 1.04 = 374.19 \text{ K}$$

17. (e) : Depression in freezing point, $\Delta T_f = iK_f m$

where, i = van't Hoff factor

K_f = Molal cryoscopic constant, m = molality

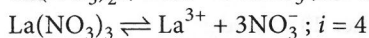
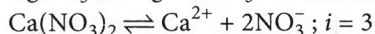
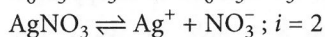
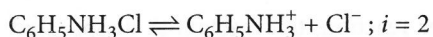
$$\text{Also, } \Delta T_f = T_f^\circ - T_f$$

where T_f° = Freezing point of pure solvent

T_f = Freezing point of solution

$$\text{or, } T_f = T_f^\circ - \Delta T_f$$

Lesser the ΔT_f value, higher will be the freezing point of the solution.



D -fructose does not ionise, thus $i = 1$

Thus, ΔT_f will be minimum for D -fructose, hence, its aqueous solution has highest freezing point.

18. (b) : Volume of CCl_4 = 500 mL

Density of CCl_4 = 1.60 g/mL

$$\therefore \text{Mass of } \text{CCl}_4 (w_1) = 500 \times 1.60 = 800 \text{ g}$$

$$\text{Mass of naphthalene } (w_2) = 51.2 \text{ g}$$

$$\text{Now, } m = \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} = \frac{51.2 \times 1000}{128 \times 800} = 0.500 \text{ m}$$

19. (b) : $\Delta T_f = K_f \times m$

$$= K_f \times \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} = 2 \times \frac{31 \times 1000}{62 \times 500} = 2$$

$$\therefore \text{Freezing point of solution} = 273 - 2 = 271 \text{ K}$$

$$20. (c) : \frac{p^\circ - p_s}{p^\circ} = \frac{n_2}{n_1 + n_2}$$

$$n_2 = \frac{18}{180} = 0.1 \quad n_1 = \frac{178.2}{18} = 9.9$$

$$p^\circ = 760 \text{ mm Hg}$$

$$\frac{760 - p_s}{760} = \frac{0.1}{9.9 + 0.1} = 0.01$$

$$760 - p_s = 760 \times 0.01 \Rightarrow 760 - p_s = 7.6$$

$$p_s = 760 - 7.6 = 752.4 \text{ mm of Hg}$$

21. (a) : Acetone - Carbon disulphide

$\Rightarrow$ Positive deviation

Acetone - Chloroform $\Rightarrow$ Negative deviation

Bromobenzene - Chlorobenzene $\Rightarrow$ Ideal

Benzene - Toluene $\Rightarrow$ Ideal

Phenol - Aniline $\Rightarrow$ Negative deviation



Chemical Kinetics

- Thermal decomposition of a compound X follows first order kinetics. The initial concentration of X is 2 mol L^{-1} . It decreased to 0.125 mol L^{-1} in one hour at 400 K. What is the half-life period of the reaction at 400 K? ($\log 2 = 0.3010$)
 (a) 15 min (b) 20 min
 (c) 30 min (d) 25 min
 (e) 10 min (2024)
- Some enzyme catalysed reactions which occur at metal surfaces are
 (a) first order reactions
 (b) second order reactions
 (c) third order reactions
 (d) fractional order reactions
 (e) zero order reactions. (2024)
- The rate and the rate constant of a reaction has the same units. The order of the reaction is
 (a) one (b) two
 (c) three (d) zero
 (e) half (2024)
- For the reaction $2A + B \rightarrow 2C + D$, the following kinetic data were obtained for three different experiments performed at the same temperature.

Experiment	$[A]_0/\text{M}$	$[B]_0/\text{M}$	Initial rate/ M s^{-1}
I	0.10	0.10	0.10
II	0.20	0.10	0.40
III	0.20	0.20	0.40

 The total order and order in [B] for the reaction are respectively
 (a) 2, 1 (b) 1, 1 (c) 1, 2 (d) 2, 2
 (e) 2, 0 (2024)
- Radioactive decay follows
 (a) first order (b) second order
 (c) third order (d) zero order
 (e) pseudo first order (2024)
- The half life period of a first order reaction is 1000 seconds. Its rate constant is
 (a) 0.693 sec^{-1} (b) $6.93 \times 10^{-2} \text{ sec}^{-1}$
 (c) $6.93 \times 10^{-3} \text{ sec}^{-1}$ (d) $6.93 \times 10^{-4} \text{ sec}^{-1}$
 (e) $6.93 \times 10^{-1} \text{ sec}^{-1}$ (2024)
- The rate constant of a first order reaction is $4.606 \times 10^{-3} \text{ s}^{-1}$. The time taken to reduce 20 g of reactant into 2 g is
 (a) 300 s (b) 500 s (c) 150 s (d) 400 s
 (e) 250 s (2024)
- The rate law for the reaction, $A + B \rightarrow \text{Product}$ is, $\text{rate} = [A][B]^{3/2}$
 The total order of the reaction is
 (a) 3 (b) 2.5 (c) 3.5 (d) 1.5
 (e) 2 (2024)
- In a zero-order reaction, the reactant A disappeared with a rate of reaction, $k = 0.04 \text{ M sec}^{-1}$. The initial concentration of A is 1 M. What will be the concentration of A after 20 seconds?
 (a) 1.08 M (b) 0.2 M (c) 0.8 M (d) 0.002 M
 (e) 0.008 M (2023)
- Find the correct combination about the following plots (P, Q and R) for the variation of rate of reaction with time.

P

Q

R

 (a) Q = Reversible; P = Zero order; R = Irreversible
 (b) R = Zero order; P = Zero order; R = Irreversible
 (c) Q = Irreversible; R = Reversible; P = Zero order
 (d) P = Irreversible; Q = Reversible; R = Zero order
 (e) P = Reversible; Q = Zero order; R = Irreversible (2023)
- In a reaction $3A \rightarrow \text{Products}$, the concentration of A decreases from 0.4 mol L^{-1} to 0.1 mol L^{-1} in 20 minutes at 300 K. The rate of decrease in [A] during this interval (in $\text{mol L}^{-1} \text{ min}^{-1}$) at 300 K is
 (a) 0.005 (b) 0.015 (c) 0.001 (d) 0.15
 (e) 0.05 (2022)
- The half-life period of a first order reaction at 298 K is 20 minutes. The time (in min.) required for 99.9% completion of the reaction at the same temperature, is
 (a) 100 (b) 200 (c) 150 (d) 250
 (e) 300 (2022)

13. For reaction $2P + Q \rightleftharpoons P_2Q$, the rate of formation of P_2Q is $0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$. Then the rates of disappearance of P and Q respectively are
 (a) $-0.48 \text{ mol dm}^{-3} \text{ s}^{-1}$ and $-0.48 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (b) $-0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$ and $-0.48 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (c) $-0.48 \text{ mol dm}^{-3} \text{ s}^{-1}$ and $-0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (d) $-0.12 \text{ mol dm}^{-3} \text{ s}^{-1}$ and $-0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (e) $-0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$ and $-0.12 \text{ mol dm}^{-3} \text{ s}^{-1}$ (2021)

14. The rate constant of a first order reaction is $231 \times 10^{-5} \text{ s}^{-1}$. How long will 4 g of this reactant reduce to 2 g?
 (a) 310 s (b) 300 s (c) 210 s (d) 30.1 s
 (e) 230.3 s (2020)

15. An endothermic reaction $A \rightarrow B$ has an activation energy of 13 kJ mol^{-1} and the enthalpy change for the reaction is 2 kJ mol^{-1} . The activation energy of the reaction $B \rightarrow A$ is
 (a) 15 kJ mol^{-1} (b) 11 kJ mol^{-1}
 (c) 2 kJ mol^{-1} (d) -15 kJ mol^{-1}
 (e) 26 kJ mol^{-1} (2020)

16. For a first order reaction, $A_{(g)} \rightarrow B_{(g)}$ at 35°C , the volume of "A" left in the reaction vessel at various times are given below. [Given data : $\log(5/4) = 0.0969$]

t/minutes	0	10	20	30	40
V/mL	25	20	15.7	12.5	9.6

What is the value of rate constant?

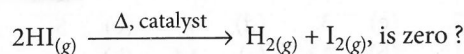
- (a) 0.02231 min^{-1} (b) 0.04231 min^{-1}
 (c) 0.06231 min^{-1} (d) 0.08231 min^{-1}
 (e) 0.1231 min^{-1} (2019)
17. In NH_3 synthesis by Haber's process, what is the effect on the rate of the reaction with the addition of Mo and CO, respectively?
 (a) Increases and decreases.
 (b) Decreases and decreases.
 (c) Decreases and increases.
 (d) Both Mo and CO increases the rate.
 (e) Both Mo and CO does not affect the rate. (2018)

18. The data given below are for the reaction of A and D_2 to form product at 295 K. Find the correct rate expression for this reaction.

$\text{D}_2/\text{mol L}^{-1}$	$\text{A}/\text{mol L}^{-1}$	Initial rate/ $\text{mol L}^{-1} \text{ s}^{-1}$
0.05	0.05	1×10^{-3}
0.15	0.05	3×10^{-3}
0.05	0.15	9×10^{-3}

- (a) $k[\text{D}_2]^1 [\text{A}]^2$ (b) $k[\text{D}_2]^2 [\text{A}]^1$
 (c) $k[\text{D}_2]^1 [\text{A}]^1$ (d) $k[\text{D}_2]^2 [\text{A}]^2$
 (e) $k[\text{D}_2]^1 [\text{A}]^0$ (2018)
19. Find the unit of the rate constant of a reaction represented with a rate equation, $\text{rate} = k[\text{A}]^{1/2} [\text{B}]^{3/2}$
 (a) $\text{mol}^{-1} \text{ L s}^{-1}$ (b) s^{-1}
 (c) $\text{mol L}^{-1} \text{ s}^{-1}$ (d) $\text{mol}^{-2} \text{ L}^2 \text{ s}^{-1}$
 (e) $\text{mol}^{-3} \text{ L}^3 \text{ s}^{-1}$ (2018)

20. Under what condition the order of reaction,



- (a) At high temperature
 (b) At high partial pressure of HI
 (c) At low partial pressure of HI
 (d) At high partial pressure of H_2
 (e) At high partial pressure of I_2 (2018)
21. Which of the following is not true about a catalyst?
 (a) Mechanism of the reaction in presence and absence of catalyst could be different.
 (b) Enthalpy of the reaction does not change with catalysts.
 (c) Catalyst enhances both forward and backward reaction at equal rate.
 (d) Catalyst participates in the reaction, but not consumed in the process.
 (e) Use of catalyst cannot change the order of the reaction. (2017)

22. In the $\ln K$ vs $\frac{1}{T}$ plot of a chemical process having $\Delta S^\circ > 0$ and $\Delta H^\circ < 0$ the slope is proportional to (where K is equilibrium constant)
 (a) $-|\Delta H^\circ|$ (b) $|\Delta H^\circ|$
 (c) ΔS° (d) $-\Delta S^\circ$
 (e) ΔG° (2017)

23. The rate constant of the reaction, $2\text{N}_2\text{O}_5 \longrightarrow 4\text{NO}_2 + \text{O}_2$ at 300 K is $3 \times 10^{-5} \text{ s}^{-1}$. If the rate of the reaction at the same temperature is $2.4 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$, then the molar concentration of N_2O_5 is
 (a) 0.4 M (b) 0.8 M
 (c) 0.04 M (d) 0.08 M
 (e) 0.6 M (2016)

24. In the reaction $A \rightarrow \text{Products}$, when the concentration of A was reduced from $2.4 \times 10^{-2} \text{ M}$ to $1.2 \times 10^{-2} \text{ M}$ the rate decreased 8 times at the same temperature. The order of the reaction is
 (a) 0 (b) 1 (c) 2 (d) 3
 (e) 0.5 (2016)

25. The half-life period of a first order reaction having rate constant $k = 0.231 \times 10^{-10} \text{ s}^{-1}$ will be
 (a) $32 \times 10^{10} \text{ s}$ (b) $2 \times 10^{10} \text{ s}$
 (c) $3 \times 10^{10} \text{ s}$ (d) $2 \times 10^{-10} \text{ s}$
 (e) $3 \times 10^{-12} \text{ s}$ (2015)

26. For the reaction $X \rightarrow Y$, the concentrations of 'X' are 1.2 M, 0.6 M, 0.3 M and 0.15 M at 0, 1, 2 and 3 hours respectively. The order of the reaction is
 (a) zero (b) half
 (c) one (d) two
 (e) three. (2015)

Answer Keys

1. (a) 2. (e) 3. (d) 4. (e) 5. (a) 6. (d) 7. (b) 8. (b) 9. (b) 10. (d)
 11. (a) 12. (b) 13. (c) 14. (b) 15. (b) 16. (a) 17. (a) 18. (a) 19. (a) 20. (b)
 21. (e) 22. (b) 23. (b) 24. (d) 25. (c) 26. (c)

Hints & Explanations

1. (a) : From first order kinetics

$$k = \frac{1}{t} \ln \frac{a}{a-x}$$

$$k = \frac{1}{60} \ln \frac{2}{0.125}$$

$$k = \frac{1}{60} \ln 16$$

$$k = \frac{1}{60} \times 2.772$$

$$k = 0.046$$

$$t_{1/2} = \frac{0.693}{k}$$

$$= \frac{0.693}{0.046}$$

$$= 15.06 \approx 15 \text{ min}$$

2. (e) : Some enzyme catalysed reactions and reactions which occur on metal surfaces are examples of zero order reactions.

3. (d) : For a zero order reaction, $R \longrightarrow P$

$$\text{Rate} = -\frac{d[R]}{dt} = k[R]^0$$

$$\text{or, Rate} = k$$

The unit of rate and rate constant for a zero order reaction is $\text{mol L}^{-1}\text{s}^{-1}$.

4. (e) : Rate of the reaction $= k[A]^x [B]^y$

From the given table,

$$0.1 = k[0.1]^x [0.1]^y \quad \dots(i)$$

$$0.4 = k[0.2]^x [0.1]^y \quad \dots(ii)$$

$$0.4 = k[0.2]^x [0.2]^y \quad \dots(iii)$$

On dividing eqn. (ii) by (i), we get

$$4 = 2^x$$

$$\Rightarrow x = 2$$

On dividing eqn. (iii) by (ii), we get

$$1 = 2^y \Rightarrow y = 0$$

Hence, the total order $= x + y = 2 + 0 = 2$

Order with respect to $B = 0$

5. (a) : Radioactive decay follows first order kinetics.

6. (d) : Half life period of 1st order reaction

$$\Rightarrow t_{1/2} = \frac{0.693}{k}$$

$$\text{Given } t_{1/2} = 1000 \text{ sec}$$

$$k = \frac{0.693}{1000} = 6.93 \times 10^{-4} \text{ sec}^{-1}$$

7. (b) : Given : $k = 4.606 \times 10^{-3} \text{ s}^{-1}$,

Initial amount = 20 g; Final amount = 2 g

$$k = \frac{2.303}{t} \log \frac{[a]}{[a-x]} \Rightarrow t = \frac{2.303}{4.6 \times 10^{-3}}$$

$$t = \frac{1000}{2} = 500 \text{ s}$$

8. (b) : Rate $= [A]^1 [B]^{3/2}$

$$\text{order} = 1 + \frac{3}{2} = \frac{2+3}{2} = \frac{5}{2} = 2.5$$

9. (b) : Rate constant, $k = 0.04 \text{ M sec}^{-1}$

Initial concentration of A i.e., $[A]_0 = 1 \text{ M}$

After, $t = 20 \text{ sec}$, conc. of A $= [A]_t$

For zero order reaction,

$$k = \frac{[A]_0 - [A]_t}{t}$$

$$\text{or, } kt = [A]_0 - [A]_t \text{ or, } [A]_t = [A]_0 - kt$$

$$= 1 - (0.04 \times 20) = 1 - 0.8 = 0.2 \therefore [A]_t = 0.2 \text{ M}$$

10. (d) : R is graph of zero order reaction. Q shows equilibrium which is possible only for reversible reaction. P shows irreversibility.

11. (a) : Reaction, $3A \rightarrow \text{Products}$

Initial conc. $(x_1) = 0.4 \text{ mol L}^{-1}$

Final conc. $(x_2) = 0.1 \text{ mol L}^{-1}$

Time interval = 20 min

$$\begin{aligned} \text{Average rate of reaction} &= \frac{-(x_2 - x_1)}{3(t_2 - t_1)} = \frac{0.3}{20 \times 3} \\ &= 0.005 \text{ mol L}^{-1}\text{min}^{-1} \end{aligned}$$

12. (b) : $t_{1/2} = 20 \text{ min}$

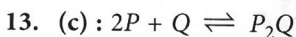
$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{20} \text{ min}^{-1}$$

For first order reaction,

$$t = \frac{2.303}{k} \log \frac{a}{a-x} = \frac{2.303}{0.693} \times 20 \log \frac{100}{0.1}$$

$$= \frac{2.303}{0.693} \times 20 \log 10^3$$

$$= \frac{3 \times 20 \times 2.303}{0.693} = 199.39 \approx 200 \text{ min}$$

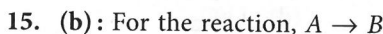


$$\frac{-1}{2} \frac{d[P]}{dt} = \frac{-d[Q]}{dt} = \frac{+d[P_2Q]}{dt}$$

$$\frac{-d[Q]}{dt} = \frac{d[P_2Q]}{dt} = 0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$$

$$\frac{-d[P]}{dt} = 2 \times \frac{d[P_2Q]}{dt} = 0.48 \text{ mol dm}^{-3} \text{ s}^{-1}$$

14. (b) : $t = \frac{2.303}{k} \log \frac{[R]_0}{[R]} = \frac{2.303}{231 \times 10^{-5}} \log \left(\frac{4}{2} \right)$
 $= 996.9 \times 0.3010 = 300 \text{ s}$



Activation energy = 13 kJ mol^{-1}

Enthalpy change for the reaction = 2 kJ mol^{-1}

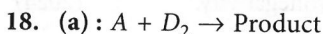
For endothermic reaction, activation energy of backward reaction is equal to the difference of activation energy of forward reaction and the enthalpy change of reaction, i.e., for $B \rightarrow A$.

Activation energy = 11 kJ mol^{-1}

16. (a) : $k = \frac{2.303}{t} \log \left(\frac{V_0}{V_t} \right)$

$$k = \frac{2.303}{10} \log \frac{25}{20} = \frac{2.303}{10} \times 0.0969 = 0.02231 \text{ min}^{-1}$$

17. (a)



Suppose rate law expression for the reaction is

$$\text{Rate} = k[D_2]^x [A]^y$$

$$1 \times 10^{-3} = k[0.05]^x [0.05]^y \quad \dots(i)$$

$$3 \times 10^{-3} = k[0.15]^x [0.05]^y \quad \dots(ii)$$

$$9 \times 10^{-3} = k[0.05]^x [0.15]^y \quad \dots(iii)$$

From equations (i) and (ii), we get

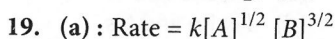
$$\frac{1 \times 10^{-3}}{3 \times 10^{-3}} = \frac{[0.05]^x}{[0.15]^x} ; \frac{1}{3} = \frac{1}{3^x} \Rightarrow x = 1$$

From equations (i) and (iii), we get

$$\frac{1 \times 10^{-3}}{9 \times 10^{-3}} = \frac{(0.05)^y}{(0.15)^y} ; \frac{1}{9} = \frac{1}{3^y} \Rightarrow y = 2$$

Thus, rate law expression is

$$\text{Rate of reaction} = k[D_2]^1 [A]^2$$



$$k = \frac{\text{rate}}{[A]^{1/2} [B]^{3/2}} = \frac{\text{mol L}^{-1} \text{ s}^{-1}}{[\text{mol L}^{-1}]^{1/2} [\text{mol L}^{-1}]^{3/2}}$$

$$= \text{mol}^{-1} \text{ L s}^{-1}$$

20. (b)

21. (e) : Use of catalyst may change the order of the reaction as the reaction mechanism in presence of catalyst could be different than that in absence of it.

22. (b) : $\Delta S^\circ > 0$

$$\Delta H^\circ < 0$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \quad \dots(i)$$

$$\Delta G^\circ = -RT \ln K \quad \dots(ii)$$

$$\text{Then, } -RT \ln K = \Delta H^\circ - T\Delta S^\circ$$

$$\ln K = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$$

On plotting $\ln K$ vs $\frac{1}{T}$, a straight line graph is obtained

with slope equal to $-\frac{\Delta H^\circ}{R}$ or $\frac{|\Delta H^\circ|}{R}$

23. (b) : Rate constant, $k = 3 \times 10^{-5} \text{ s}^{-1}$

From the unit of k it is clear that the reaction is of first order.

$$\Rightarrow \text{Rate} = k[\text{N}_2\text{O}_5]$$

$$\Rightarrow [\text{N}_2\text{O}_5] = \frac{\text{Rate}}{k} = \frac{2.4 \times 10^{-5}}{3 \times 10^{-5}} \text{ mol dm}^{-3}$$

$$= 0.8 \text{ mol dm}^{-3}$$

24. (d) : $\frac{r_1}{r_2} = \left[\frac{2.4 \times 10^{-2}}{1.2 \times 10^{-2}} \right]^x$

$$8 = (2)^x \Rightarrow (2)^3 = (2)^x$$

$$\therefore x = 3$$

Hence, the order of reaction is 3.

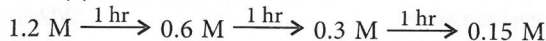
25. (c) : For a first order reaction $t_{1/2} = \frac{0.693}{k}$

$$\text{Given : } k = 0.231 \times 10^{-10} \text{ s}^{-1}$$

$$t_{1/2} = \frac{0.693}{0.231 \times 10^{-10}} \text{ s}$$

$$t_{1/2} = 3 \times 10^{10} \text{ s}$$

26. (c) : Concentration of 'X'



The concentration is reduced to exactly half after every hour of a reaction. Thus, $t_{1/2}$ of the reaction is independent of the concentration of the reactant and hence it is a first order reaction.



d-and *f*-Block Elements

- The correct electronic configuration of Tc ($Z = 43$) is
 (a) $[\text{Kr}] 4d^6 5s^1 5p^0$ (b) $[\text{Kr}] 4d^3 5s^1 5p^3$
 (c) $[\text{Kr}] 4d^5 5s^2 5p^0$ (d) $[\text{Kr}] 4d^7 5s^0 5p^0$
 (e) $[\text{Kr}] 4d^4 5s^2 5p^1$ (2024)
- Which of the following 3*d* block element exhibits +2, +3, +4, +5, +6 and +7 oxidation states?
 (a) Titanium (b) Vanadium
 (c) Chromium (d) Manganese
 (e) Iron (2024)
- Which lanthanide element has half-filled 4*f* orbitals in its +3 state?
 (a) Terbium (b) Gadolinium
 (c) Cerium (d) Lanthanum
 (e) Lutetium (2024)
- The 3*d* block metal having positive standard electrode potential (M^{2+}/M) is
 (a) titanium (b) vanadium
 (c) iron (d) copper
 (e) chromium. (2024)
- Which of the following statement is incorrect with regard to interstitial compounds of transition elements?
 (a) They have high melting points.
 (b) They are very hard.
 (c) They have metallic conductivity.
 (d) They are chemically inert.
 (e) They are stoichiometric compounds. (2024)
- The alloy containing about 95% lanthanoids, 5% iron and traces of S, C, Ca and Al which is used in producing Mg-based bullets is
 (a) bell metal (b) monel metal
 (c) misch metal (d) bronze
 (e) german silver (2024)
- The electronic configuration of Pd ($Z = 46$) is
 (a) $[\text{Kr}] 4d^8 5s^2 5p^0$ (b) $[\text{Kr}] 4d^9 5s^1 5p^0$
 (c) $[\text{Kr}] 4d^{10} 5s^0 5p^0$ (d) $[\text{Kr}] 4d^5 5s^2 5p^3$
 (e) $[\text{Kr}] 4d^6 5s^2 5p^2$ (2024)
- Which of the following tripositive ion has smallest size?
 (a) Ce^{3+} (b) Nd^{3+} (c) La^{3+} (d) Sm^{3+}
 (e) Gd^{3+} (2024)
- Lanthanides (Ln) when heated with carbon at 2773 K form product with general formula
 (a) LnC (b) Ln_2C_3
 (c) LnC_3 (d) LnC_2
 (e) Ln_3C_2 (2024)
- Which of the following is an acidic oxide?
 (a) CrO_3 (b) CrO (c) V_2O_4 (d) V_2O_5
 (e) V_2O_3 (2024)
- The catalyst used in the Wacker process is
 (a) V_2O_5 (b) PdCl_2
 (c) TiCl_4 with $\text{Al}(\text{CH}_3)_3$ (d) Fe
 (e) Mo (2024)
- Transition elements act as catalyst because
 (a) their melting points are high
 (b) their ionization potential values are high
 (c) they have high density
 (d) they show variable oxidation state
 (e) they have high electronegativity. (2024)
- Lanthanides (Ln) burn in O_2 to give
 (a) LnO (b) $\text{Ln}(\text{OH})_3$
 (c) Ln_2O_3 (d) LnO_2
 (e) LnO_3 (2024)
- The structure of MnO_4^- ion is
 (a) square planar (b) octahedral
 (c) trigonal pyramid (d) pyramid
 (e) tetrahedral. (2024)
- The reaction, $2\text{I}^- + \text{S}_2\text{O}_8^{2-} \rightarrow \text{I}_2 + 2\text{SO}_4^{2-}$, is catalysed by
 (a) Iron(II) (b) Manganese(VI)
 (c) Iron(III) (d) Vanadium(V)
 (e) Cobalt(III) (2024)
- Which one of the following set of transition metals have high volatility?
 (a) Ti, Zn and Hf (b) Cr, Mo and W
 (c) Mn, Tc and Re (d) Fe, Ru and Os
 (e) Zn, Cd and Hg (2022)
- Both Cr^{2+} and Mn^{3+} have d^4 configuration. Which one of the following is true?
 (a) Mn^{3+} is a reducing agent but Cr^{2+} is an oxidising agent.
 (b) Mn^{3+} is an oxidising agent but Cr^{2+} is a reducing agent.
 (c) Both Mn^{3+} and Cr^{2+} are oxidising agents.
 (d) Both Mn^{3+} and Cr^{2+} are reducing agents.
 (e) Both Mn^{3+} and Cr^{2+} are neither reducing nor oxidising agents. (2022)

18. Which one of the following actinoid has no electron in 6d orbital?
(a) Pa (b) Np (c) Lr (d) Cm (e) Pu (2020)
19. An orange solid (A) on heating gives a green residue (B), colourless gas (C) and water vapours. The dry gas (C) upon passing over heated Mg gave a white solid (D) which upon subsequent reaction with water gave a gas (E) that gave dense white fumes with HCl. Identify (D).
(a) $\text{Fe}(\text{NH}_3)\text{Cl}_2$ (b) CuN_2
(c) Mg_3N_2 (d) NH_4Cl
(e) FeCl_2 (2019)
20. When H_2O_2 is added to an acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution
(a) a green colour solution is obtained
(b) a yellow solution is obtained
(c) a blue-violet solution is obtained
(d) a green precipitate is formed
(e) a yellow precipitate is formed. (2018)
21. How many peroxy linkages are present in CrO_5 ?
(a) 1 (b) 2
(c) 3 (d) 4
(e) 5 (2018)
22. When MnO_2 is fused with KOH and KNO_3 , a coloured compound is formed. Choose the right compound with the appropriate colour.
(a) K_2MnO_4 , green (b) KMnO_4 , purple
(c) Mn_2O_3 , brown (d) Mn_3O_4 , black
(e) MnO_2 , black (2017)
23. Identify the case(s) where there is change in oxidation number.
(a) Acidified solution of CrO_4^{2-}
(b) SO_2 gas bubbled through an acidic solution of $\text{Cr}_2\text{O}_7^{2-}$
(c) Alkaline solution of $\text{Cr}_2\text{O}_7^{2-}$
(d) Ammoniacal solution of CrO_4^{2-}
(e) Aqueous solution of CrO_2Cl_2 in NaOH. (2017)
24. Choose the wrong statement in the following.
(a) TiO_2 is used in the pigment industry.
(b) MnO_2 is used in dry battery cells.
(c) V_2O_5 catalyses the oxidation of SO_2 in the manufacture of sulphuric acid.
(d) Ziegler catalyst is used in the manufacture of high density polyethylene.
(e) The 'silver' UK coins are made of Ag/Ni alloy. (2016)
25. In aqueous solution, Cr^{2+} is stronger reducing agent than Fe^{2+} . This is because
(a) Cr^{2+} ion is more stable than Fe^{2+}
(b) Cr^{3+} ion with d^3 configuration has favourable crystal field stabilisation energy
(c) Cr^{3+} has half-filled configuration and hence more stable
(d) Fe^{3+} in aqueous solution is more stable than Cr^{3+}
(e) Fe^{2+} ion with d^6 configuration has favourable crystal field stabilisation energy. (2016)
26. Choose the correct matching of transition metal ion and magnetic moment from the codes given below :
(At. No : Ti = 22, V = 23, Fe = 26)
- | Transition element | | Magnetic moment (B.M.) | |
|--------------------|----------------|------------------------|------|
| (A) | Titanium (III) | (1) | 4.9 |
| (B) | Vanadium (II) | (2) | 1.73 |
| (C) | Iron (II) | (3) | 3.87 |
- (a) (A) - (2), (B) - (3), (C) - (1)
(b) (A) - (2), (B) - (1), (C) - (3)
(c) (A) - (1), (B) - (2), (C) - (3)
(d) (A) - (1), (B) - (3), (C) - (2)
(e) (A) - (3), (B) - (2), (C) - (1) (2016)
27. The hardest lanthanide element is
(a) Sm (b) La (c) Gd (d) Dy
(e) Yb (2015)

Answer Keys

1. (c) 2. (d) 3. (b) 4. (d) 5. (e) 6. (c) 7. (c) 8. (e) 9. (d) 10. (a)
11. (b) 12. (d) 13. (c) 14. (e) 15. (c) 16. (e) 17. (b) 18. (e) 19. (c) 20. (a)
21. (b) 22. (a) 23. (b) 24. (e) 25. (b) 27. (a) 27. (a)

Hints & Explanations

1. (c) : Technetium (Tc) is a d-block element with electronic configuration of $[\text{Kr}]4d^5 5s^2 5p^0$.

2. (d) :

Element	Oxidation states
Ti	+2, +3, +4
V	+2, +3, +4, +5
Cr	+2, +3, +4, +5, +6

Mn	+2, +3, +4, +5, +6, +7
Fe	+2, +3, +4, +6

3. (b) : $\text{Gd} : [\text{Xe}] 4f^7 5d^1 6s^2$
 $\text{Gd}^{3+} : [\text{Xe}] 4f^7$

4. (d) : $E_{\text{Cu}^{2+}/\text{Cu}}^\circ = +0.34 \text{ V}$

The unique behaviour of Cu, having a positive E° , accounts for its inability to liberate H_2 from acids.

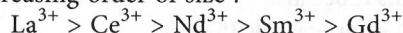
5. (e) : Interstitial compounds of transition metals are usually non-stoichiometric compounds.

6. (c) : Mischmetall is an alloy which consists of a lanthanoid metal (~95%) and iron (~5%) and traces of S, C, Ca and Al. It is used in Mg based alloy to produce bullets.

7. (c) : Electronic configuration of ${}_{46}\text{Pd} = [\text{Kr}]4d^{10} 5s^0$

8. (e) : Gd^{3+} has smallest size among all the given tripositive ion due to lanthanoid contraction.

Decreasing order of size :



9. (d) : $\text{Ln} + \text{C} \xrightarrow{2773 \text{ K}} \text{LnC}_2$

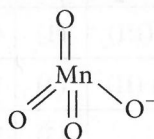
10. (a) : CrO_3 is an acidic oxide.

11. (b) : Wacker process refer to the oxidation of ethylene to acetaldehyde in presence of Palladium (II) chloride and copper (II) chloride as the catalyst.

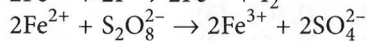
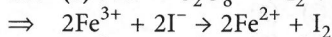
12. (d) : Transition elements act as catalyst because they show variable oxidation state.

13. (c) : Lanthanoid shows (+3) oxidation state, they resemble Ln chemical reactivity. So the reaction of in with O_2 is $\text{Ln} + \text{O}_2 \rightarrow \text{Ln}_2\text{O}_3$

14. (e) : Structure of MnO_4^- : Tetrahedral



15. (c) : $2\text{I}^- + \text{S}_2\text{O}_8^{2-} \rightarrow \text{I}_2 + 2\text{SO}_4^{2-}$ Fe^{3+} act as catalyst.

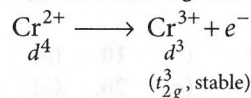


16. (e) : Zn, Cd and Hg have low boiling point due to fully filled d -orbitals so they are highly volatile.

17. (b) : $\text{Mn}^{3+} + e^- \longrightarrow \text{Mn}^{2+}$

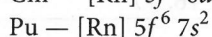
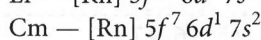
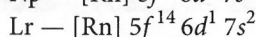
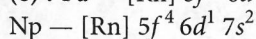
d^4 d^5
(half filled, stable)

Hence, Mn^{3+} is good oxidising agent.



Hence, Cr^{2+} is strong reducing agent.

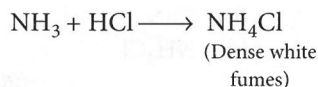
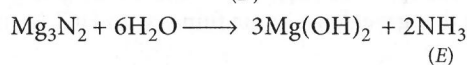
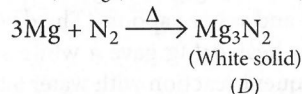
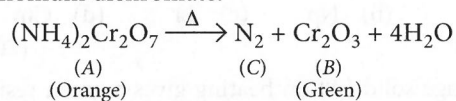
18. (e) : Pa — $[\text{Rn}] 5f^2 6d^1 7s^2$



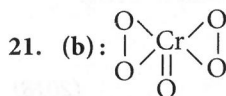
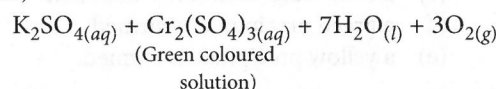
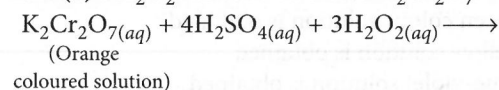
19. (c) : Formation of dense white fumes with HCl indicates that the gas (E) is NH_3 .

Ammonia is formed by hydrolysis of solid (D). Thus, (D) should be Mg_3N_2 .

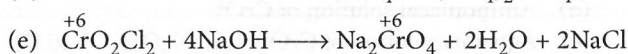
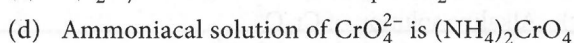
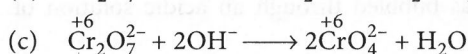
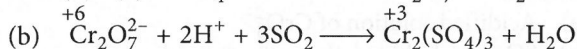
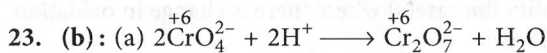
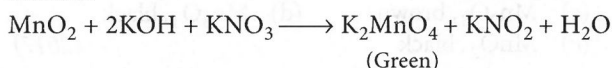
Formation of (D) indicates that gas (C) is N_2 . Thus, (A) is ammonium dichromate.



20. (a) : H_2O_2 reduced acidified $\text{K}_2\text{Cr}_2\text{O}_7$.



22. (a) : When MnO_2 is fused with KOH in the presence of oxidising agent such as potassium nitrate (KNO_3), a green coloured compound, potassium manganate, (K_2MnO_4) is formed.



24. (e) : The silver UK coins are made of Cu-Ni alloy.

25. (b) : Cr^{3+} ion with d^3 (t_{2g}^3) configuration has favourable crystal field stabilisation energy.

26. (a) : Magnetic moment, $\mu = \sqrt{n(n+2)}$ B.M.

Ion	Electronic Configuration	Number of unpaired electrons	μ
Ti^{3+}	d^1	1	1.73
V^{2+}	d^3	3	3.87
Fe^{2+}	d^6	4	4.90

27. (a) : Hardness increases with increasing atomic number. Sm is exceptionally hard like steel.

Coordination Compounds

- The IUPAC name of the coordination compound $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})\text{Cl}]\text{Cl}_2$ is
 - Tetraammineaquachloridocobalt(III) chloride
 - Aquatetraamminechloridocobalt(III) chloride
 - Chloridotetraammineaquacobalt(II) chloride
 - Tetraamminechloridoaquacobalt(III) dichloride
 - Tetraamminechloridoaquacobalt(II) dichloride.

(2024)
- Coordination compounds exhibit different types of isomerism. Some complexes are given in column-I and type of isomerism is given in column-II.

	Column-I		Column-II
(A)	$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$	(i)	ionisation isomerism
(B)	$[\text{Co}(\text{en})_3]^{3+}$	(ii)	linkage isomerism
(C)	$[\text{Cr}(\text{NH}_3)_5(\text{SO}_4)]\text{Br}$	(iii)	optical isomerism
(D)	$[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$	(iv)	geometrical isomerism

Choose the correct matching from the codes given below:

 - (A)-(ii), (B)-(iv), (C)-(i), (D)-(iii)
 - (A)-(iv), (B)-(i), (C)-(ii), (D)-(iii)
 - (A)-(iv), (B)-(iii), (C)-(i), (D)-(ii)
 - (A)-(iv), (B)-(ii), (C)-(iii), (D)-(i)
 - (A)-(iii), (B)-(ii), (C)-(iv), (D)-(i)

(2024)
- The IUPAC name of the complex $[\text{Cr}(\text{NH}_3)_3(\text{H}_2\text{O})_3]\text{Cl}_3$ is
 - triaquatramminechromium(III) chloride
 - triamminetriaquachromium(III) chloride
 - triaquatramminechromium(II) chloride
 - triamminetriaquachromium(II) chloride
 - triaquatramminechromium(III) trichloride

(2024)
- The coordination number of Pt and Fe in the complexes $[\text{PtCl}_6]^{2-}$ and $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ are respectively
 - 4 and 6
 - 6 and 6
 - 4 and 4
 - 6 and 8

(2024)
- The IUPAC name of the coordination compound $\text{Hg}[\text{Co}(\text{SCN})_4]$ is
 - Mercury (I) tetrathiocyanato-S-cobaltate (III)
 - Mercury (II) tetrathiocyanato-S-cobaltate(II)
 - Mercury (I) tetrathiocyanato-S-cobaltate (IV)
 - Mercury (II) tetraisocyanato-S-cobaltate (III)
 - Mercury (I) tetraisocyanato-N-cobaltate (III)

(2024)
- The hybridisation involved in the metal atom of $[\text{CrF}_6]^{3-}$ is
 - d^2sp^3
 - dsp^2
 - sp^3d
 - sp^3
 - sp^3d^2

(2024)
- A coordination compound of cobalt acts as antipernicious anaemia factor is
 - cyanocobalamine
 - carboxypeptidase
 - $[\text{Co}(\text{NH}_3)_6]^{3+}$
 - haemoglobin
 - myoglobin

(2024)
- The type of $d-d$ transition of the electron occurs in $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ is
 - $t_{2g}^2 e_g^1 \rightarrow t_{2g}^1 e_g^2$
 - $t_{2g}^1 e_g^0 \rightarrow t_{2g}^1 e_g^0$
 - $t_{2g}^1 e_g^0 \rightarrow t_{2g}^0 e_g^1$
 - $t_{2g}^0 e_g^1 \rightarrow t_{2g}^1 e_g^0$
 - $t_{2g}^2 e_g^0 \rightarrow t_{2g}^1 e_g^1$

(2024)
- The increasing order of field strength of ligands in the spectrochemical series is
 - $\text{CO} < \text{H}_2\text{O} < \text{Cl}^- < \text{I}^-$
 - $\text{Cl}^- < \text{H}_2\text{O} < \text{CO} < \text{I}^-$
 - $\text{H}_2\text{O} < \text{CO} < \text{I}^- < \text{Cl}^-$
 - $\text{H}_2\text{O} < \text{I}^- < \text{Cl}^- < \text{CO}$
 - $\text{I}^- < \text{Cl}^- < \text{H}_2\text{O} < \text{CO}$

(2024)
- Which of the following is used in the treatment of lead poisoning?
 - EDTA
 - DMG
 - Cupron
 - α -nitroso- β -naphthol
 - $[(\text{Ph}_3\text{P})_3\text{RhCl}]$

(2024)
- The number of unpaired electrons in $[\text{CoF}_6]^{3-}$ is
 - one
 - four
 - zero
 - two
 - three.

(2024)
- The geometry of $[\text{NiCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$ ions are
 - both tetrahedral
 - both square planar
 - both octahedral
 - square planar and tetrahedral, respectively
 - tetrahedral and square planar, respectively.

(2023)

13. $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)_2]\text{Cl}$ exhibits
 (a) linkage isomerism, ionisation isomerism and optical isomerism
 (b) linkage isomerism, geometrical isomerism and ionisation isomerism
 (c) ionisation isomerism, geometrical isomerism and optical isomerism
 (d) linkage isomerism, geometrical isomerism and optical isomerism
 (e) optical isomerism, geometrical isomerism and ionisation isomerism. (2023)

14. Match the following complexes (P) with the geometry (Q).

(P)		(Q)	
A.	$[\text{Cu}(\text{NH}_3)_4]^{2+}$	(i)	Tetrahedral
B.	$[\text{Ag}(\text{NH}_3)_2]^+$	(ii)	Octahedral
C.	$[\text{Fe}(\text{CO})_5]$	(iii)	Square planar
D.	$[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$	(iv)	Trigonal bipyramidal
E.	$[\text{NiCl}_4]^{2-}$	(v)	Linear

- (a) A - (ii); B - (iii); C - (i); D - (iv); E - (v)
 (b) A - (iii); B - (v); C - (iv); D - (ii); E - (i)
 (c) A - (iv); B - (iii); C - (v); D - (i); E - (ii)
 (d) A - (v); B - (iv); C - (ii); D - (iii); E - (i)
 (e) A - (iv); B - (ii); C - (iii); D - (v); E - (i) (2023)
15. The tetrahedral crystal field splitting is only ____ of the octahedral splitting.
 (a) 1/9 (b) 2/9 (c) 3/9 (d) 4/9
 (e) 5/9 (2023)
16. Which order is correct in spectrochemical series of ligands?
 (a) $\text{Cl}^- < \text{F}^- < [\text{C}_2\text{O}_4]^{2-} < \text{H}_2\text{O} < \text{CN}^-$
 (b) $\text{Cl}^- < \text{F}^- < \text{CN}^- < \text{H}_2\text{O} < [\text{C}_2\text{O}_4]^{2-}$
 (c) $\text{F}^- < \text{Cl}^- < \text{CN}^- < \text{H}_2\text{O} < [\text{C}_2\text{O}_4]^{2-}$
 (d) $\text{F}^- < \text{Cl}^- < \text{H}_2\text{O} < \text{CN}^- < [\text{C}_2\text{O}_4]^{2-}$
 (e) $\text{Cl}^- < \text{F}^- < \text{H}_2\text{O} < [\text{C}_2\text{O}_4]^{2-} < \text{CN}^-$ (2023)
17. Geometry, hybridisation and magnetic moment of $[\text{MnBr}_4]^{2-}$, $[\text{FeF}_6]^{4-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$ ions, respectively, are
 (a) Tetrahedral, square planar, octahedral; sp^3 , dsp^3 , sp^3d^2 ; 5.9, 0, 4.9
 (b) Tetrahedral, octahedral, square planar; sp^3 , sp^3d^2 , dsp^2 ; 5.9, 4.9, 0
 (c) Octahedral, square planar, tetrahedral; sp^3d^2 , dsp^2 , sp^3 ; 4.9, 0, 5.9
 (d) Square planar, tetrahedral, octahedral; sp^3d^2 , sp^3 , dsp^2 ; 0, 4.9, 5.9
 (e) Tetrahedral, octahedral; square planar; sp^3 , sp^3d^2 , dsp^2 ; 0, 5.9, 4.9 (2023)
18. The overall complex dissociation equilibrium constant for $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ ion is 5×10^{-12} . The overall stability constant of the complex is
 (a) 2×10^{-11} (b) 5×10^{11}
 (c) 5×10^{10} (d) 2×10^{11}
 (e) 0.2×10^{11} (2022)

19. The complexes $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$ are
 (a) coordination isomers (b) geometrical isomers
 (c) solvate isomers (d) ionization isomers
 (e) linkage isomers. (2022)
20. In which one of the following complexes, the conductivity corresponds to 1 : 2 electrolyte in aqueous solution?
 (a) Hexaamminecobalt(III) chloride
 (b) Tetraamminedichlorocobalt(III) chloride
 (c) Pentaamminechlorocobalt(III) chloride
 (d) Triamminetriaquachromium(III) chloride
 (e) Diamminesilver(I) dicyanoargentate(I) (2021)
21. The magnetic moment of a trivalent ion of a metal with $Z = 24$ in aqueous solution is
 (a) 3.87 BM (b) 2.84 BM
 (c) 1.73 BM (d) 4.90 BM
 (e) 5.92 BM (2021)
22. Which one of the following is an ambidentate ligand?
 (a) Cl^- (b) H_2O
 (c) $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ (d) SCN^-
 (e) $\text{C}_2\text{O}_4^{2-}$ (2020)
23. The correct formula of dichlorobis(triphenylphosphine) nickel(II) is
 (a) $[\text{NiCl}_2(\text{PPh}_3)_2]\text{Cl}$ (b) $[\text{NiCl}_2(\text{PPh}_3)]$
 (c) $[\text{NiCl}_2(\text{PPh}_2)_3]$ (d) $[\text{NiCl}(\text{PPh}_3)_2]\text{Cl}$
 (e) $[\text{NiCl}_2(\text{PPh}_3)_2]$ (2020)
24. The donor atom in EDTA are
 (a) two N and two O (b) two N and four O
 (c) four N and two O (d) three N and three O
 (e) two N and three O. (2019)
25. Consider the following two complex ions: $[\text{CoF}_6]^{3-}$ and $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$. Which of the following statement(s) is/are false?
 I. Both are octahedral.
 II. $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ is diamagnetic while $[\text{CoF}_6]^{3-}$ is paramagnetic.
 III. Both are outer orbital complexes.
 IV. In both the complexes the central metal is in the same oxidation state.
 (a) II and III (b) II, III and IV
 (c) III only (d) III and IV
 (e) I, II and IV (2016)
26. Chlorophyll is a coordination compound of
 (a) iron (b) magnesium
 (c) manganese (d) chromium
 (e) zinc. (2016)
27. In which one of the following $d-d$ transition involves absorption in the ultraviolet region?
 (a) $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ (b) $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$
 (c) $[\text{Co}(\text{NH}_3)_6]^{3+}$ (d) $[\text{Co}(\text{CN})_6]^{3-}$
 (e) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ (2015)

28. The chelating ligand used to remove excess of copper and iron in chelate therapy is

- (a) *D*-penicillamine
(b) oxalate ion
(c) EDTA
(d) ethylenediamine
(e) dimethylglyoxime.

(2015)

29. The correct ascending order of ligand field strengths of the given ligands is

- (a) $F^- < I^- < CN^- < H_2O < CO$
(b) $I^- < F^- < H_2O < CO < CN^-$
(c) $I^- < F^- < H_2O < CN^- < CO$
(d) $F^- < H_2O < I^- < CN^- < CO$
(e) $F^- < I^- < CO < H_2O < CN^-$

(2015)

Answer Keys

1. (a) 2. (c) 3. (b) 4. (b) 5. (a) 6. (a) 7. (a) 8. (c) 9. (e) 10. (a)
11. (b) 12. (e) 13. (b) 14. (b) 15. (d) 16. (a) 17. (b) 18. (d) 19. (e) 20. (c)
21. (a) 22. (d) 23. (e) 24. (b) 25. (c) 26. (b) 27. (d) 28. (a) 29. (c)

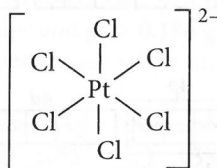
Hints & Explanations

1. (a): $[Co(NH_3)_4(H_2O)Cl]Cl_2$:

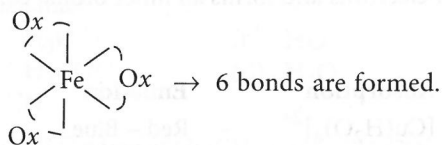
Tetraammineaquachloridocobalt(III) chloride

2. (c) 3. (b)

4. (b): Co-ordination number of Pt in $[PtCl_6]^{2-} = 6$
6-Cl-atoms are directly linked with Pt



Co-ordination number of Fe in $Fe(C_2O_4)_3^{3-}$ is also 6, as $(C_2O_4)^{2-}$ is a bidentate ligand.



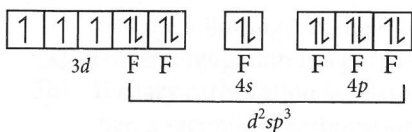
[Ox = oxalate ion]

5. (a): Hg Counter ion $\left[\begin{array}{cc} Co & (SCN)_4 \\ \text{Central} & \text{Ambidentate} \\ \text{metal atom} & \text{ligand} \end{array} \right]$

IUPAC name is

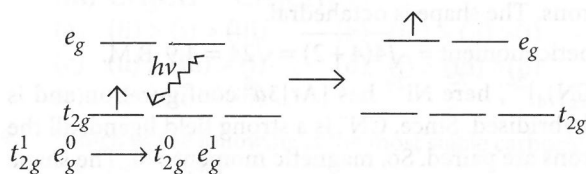
Mercury (I) tetrathiocyanato-S-cobaltate (III)

6. (a): Electronic configuration of $Cr^{3+} = [Ar]3d^3 4s^0$
6-F atoms occupy 2-d, 1-s and 3-p orbitals.

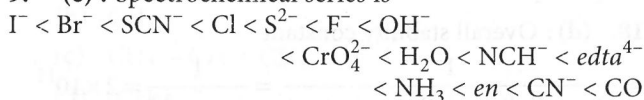


7. (a): Vitamin B-12, cyanocobalamin, the antipernicious anaemia factor, is a co-ordination compound of cobalt.

8. (c): $[Ti(H_2O)_6]^{3+}$ has $3d^1$ -electronic configuration. When radiation with suitable frequency is supplied the $1e^-$ is transferred from lower t_{2g} level to upper e_g level.



9. (e): Spectrochemical series is



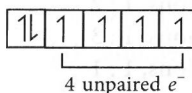
Correct option: $I^- < Cl^- < H_2O < CO$

10. (a): EDTA is injected intravenously in blood stream, it traps lead and form chelate complex that is excreted the urine.

11. (b): $_{27}Co = [Ar]4s^2 3d^7$

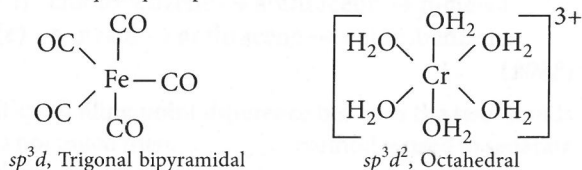
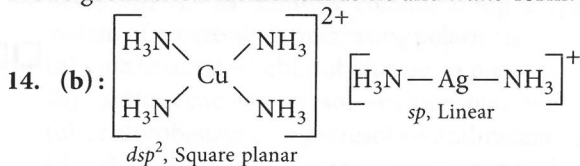
In $[CoF_6]^{3-} \Rightarrow Co^{+3} = [Ar]4s^0 3d^6$

As F^- is a weak field ligand, it form high spin complex.



12. (e): Cl^- is a weak field ligand so $[NiCl_4]^{2-}$ undergoes sp^3 hybridisation with tetrahedral geometry. CN^- is a strong field ligand, thus $[Ni(CN)_4]^{2-}$ undergoes dsp^2 hybridisation and has square planar geometry.

13. (b): $[Co(NH_3)_4(NO_2)_2]Cl$ exhibits linkage isomerism as NO_2 is an ambidentate ligand. It also exhibits ionisation isomerism due to exchange of NO_2^- and Cl^- ions. It also shows geometrical isomerism as *cis* and *trans*-form.



- (a) simple distillation
(b) distillation under reduced pressure
(c) steam distillation
(d) fractional distillation
(e) differential extraction (2017)
15. Lassaigne's test (with silver nitrate) is commonly used to detect halogens such as chlorine, bromine and iodine but not useful to detect fluorine because the product AgF formed is
(a) volatile (b) reactive
(c) explosive (d) soluble in water
(e) a liquid. (2017)
16. Glycerol can be separated from spent-lye in soap industry by
(a) crystallisation
(b) sublimation
(c) differential extraction
(d) chromatography
(e) distillation under reduced pressure. (2015)
17. Among the following, the ambident nucleophile is
(a) iodide (b) alkoxy
(c) hydroxyl (d) hydride
(e) cyanide. (2015)

Answer Keys

1. (d) 2. (b) 3. (a) 4. (e) 5. (b) 6. (b) 7. (e) 8. (d) 9. (d) 10. (d)
11. (d) 12. (d) 13. (a) 14. (d) 15. (d) 16. (e) 17. (e)

Hints & Explanations

1. (d): Mass of the compound taken = 0.14 g

Volume of nitrogen at STP = 22.4 mL

$$\% \text{ of N} = \frac{28}{22400} \times \frac{\text{Vol. of N}_2 \text{ at STP}}{\text{Mass of compound taken}} \times 100$$

$$\% \text{ of N} = \frac{28}{22400} \times \frac{22.4}{0.14} \times 100 = 20\%$$

2. (b): The given compound has 11 sigma (σ) bonds.

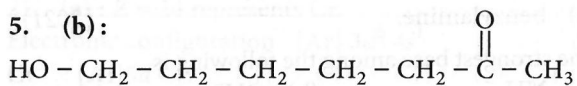
3. (a): % of bromine

$$= \frac{80}{188} \times \frac{\text{Mass of AgBr formed}}{\text{Mass of organic compound taken}} \times 100$$

$$= \frac{80}{188} \times \frac{0.188}{0.4} \times 100 = 20\%$$

4. (e): CN^- is an ambident nucleophile as it has more than one donor site.

5. (b):



(Preference is given to Keto group)

IUPAC name : 7-hydroxyheptan-2-one.

6. (b): Kjeldahl method can be used to estimate the amount of nitrogen in aniline.

7. (e): When inductive effect and electromeric effect operates in opposite direction, electromeric effect predominates. It is due to the reason that the temporary shifting of e^- in a molecule or functional group is more significant than the paramagnetic polarization of sigma bond.

8. (d): Order of stability of carbocation is $3^\circ > 2^\circ > 1^\circ$ due to inductive effect and hyperconjugation. Hence the order, is
 $(\text{CH}_3)_3\text{C}^+ > \text{CH}_3\text{CH}^+\text{CH}_2\text{CH}_3 > (\text{CH}_3)_2\text{CHCH}_2^+$
 $3^\circ \qquad \qquad 2^\circ \qquad \qquad 1^\circ$

9. (d): $\text{H}_3\text{C}-\overset{+}{\text{C}}(\text{CH}_3)-\text{CH}_3$ being 3° carbocation is the most stable.

10. (d): Carbocations being electron deficient cannot act as nucleophiles.

11. (d): Kjeldahl's method is not applicable if nitrogen is present in ring and for nitro and azo groups. As in pyridine 'N' is present in the ring, Kjeldahl's method is not applicable.



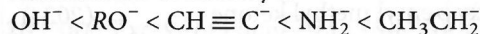
Pyridine

12. (d): Stronger the acid, weaker will be its conjugate base.

Acidic order :



Hence, order of basicity is



13. (a)

14. (d): If the boiling points of the two liquids of the mixture are close to each other, then fractional distillation method is used to separate them.

15. (d): Lassaigne's test is not used to detect fluorine in the organic compound as the product formed during this test, i.e., AgF is highly soluble in water and does not precipitate.

16. (e): Glycerol from spent-lye can be separated by distillation under reduced pressure.

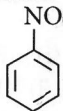
17. (e): Cyanide ion can coordinate through carbon as well as nitrogen.

Hydrocarbons

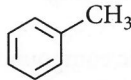
- In which of the following reaction Lindlar's catalyst is used?
 - $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3 + \text{H}_2 \longrightarrow \text{CH}_3-\text{CH}_2-\text{CH}_3-\text{CH}_3$
 - $\text{CH}_3-\text{CO}-\text{CH}_3 + \text{H}_2 \longrightarrow \text{CH}_3-\text{CH}(\text{OH})-\text{CH}_3$
 - $\text{CH}_3\text{CH}_2\text{NO}_2 + \text{H}_2 \longrightarrow \text{CH}_3\text{CH}_2\text{NH}_2$
 - $\text{C}_6\text{H}_5-\text{CHO} + \text{H}_2 \longrightarrow \text{C}_6\text{H}_5-\text{CH}_2\text{OH}$
 - $\text{CH}_3\text{C}\equiv\text{C}-\text{CH}_3 + \text{H}_2 \longrightarrow \text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$
 (2024)
- The alkene that exhibits optical isomerism is
 - 2-methyl-2-pentene
 - 3-methyl-2-pentene
 - 3-methyl-1-pentene
 - 4-methyl-1-pentene
 - 2-methylpentane
 (2024)
- Which of the following statement is incorrect with Kolbe's electrolytic method?
 - It gives an alkane with even number of carbon atoms at the anode.
 - At anode decarboxylation and formation of methyl radical occurs.
 - Methane cannot be prepared by this method.
 - At anode acetate ion accepts electrons to give acetate free radical.
 - At cathode hydrogen gas is liberated.
 (2024)
- Which of the following substitution reaction with methane requires HIO_3 as an oxidising agent?
 - Chlorination
 - Bromination
 - Iodination
 - Fluorination
 - Friedel-Crafts acylation
 (2024)
- Which of the following is the most reactive in aromatic electrophilic substitution reaction?
 - Benzene
 - Chlorobenzene
 - Phenol
 - Benzaldehyde
 - Nitrobenzene
 (2024)
- Which of the following statement is incorrect with regard to ozonolysis?
 - It involves addition of ozone on alkene.
 - An unsymmetrical alkene gives two different carbonyl compounds.
 - It is used to identify the number of double bonds in starting material.
 - It cannot be used to detect the position of the double bonds.
 - Ozonide will undergo cleavage by $\text{Zn-H}_2\text{O}$.
 (2024)
- Which of the following statement is true?
 - Dehydration of alcohol takes place in presence of HCl/ZnCl_2 .
 - Formation of ethene from ethyl iodide occurs on heating with aqueous KOH .
 - Hydrogenation of an unsymmetrical alkyne in presence of Pd/C gives *cis*-alkene.
 - Hydrogenation of an unsymmetrical alkyne in presence of Na/liq.NH_3 gives *cis*-alkene.
 - The order of reactivity of hydrogen halides towards alkenes is $\text{HI} < \text{HBr} < \text{HCl}$.
 (2024)
- One mole of an alkene on ozonolysis gives a mixture of one mole pentan-3-one and one mole methanal. The alkene is
 - 3-ethylbut-1-ene
 - 2-methylpent-1-ene
 - 2-ethylbut-1-ene
 - 4-methylpent-2-ene
 - 4-methylpent-1-ene
 (2024)
- The reagent used for the conversion of but-2-ene to ethanal is
 - anhydrous CrO_3
 - DIBAL-H
 - PCC
 - $\text{O}_3/\text{H}_2\text{O-Zn dust}$
 - anhydrous AlCl_3
 (2024)
- Which compound will not take part in the Friedel-Crafts acylation?



(i)



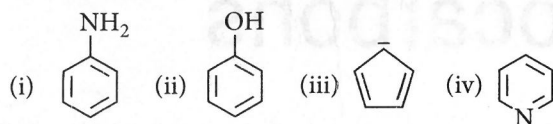
(ii)



(iii)

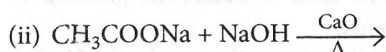
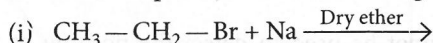
 - (ii) and (iii)
 - Only (iii)
 - (i) and (iii)
 - Only (ii)
 - Only (i)
 (2023)
- Which of the following contains sp hybridised carbon atom?
 - $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$
 - $\text{CH}_3-\text{C}\equiv\text{C}-\text{CH}_3$
 - CH_3-CH_3
 - CHCl_3
 - $\text{CH}_3-\text{CH}_2-\text{Cl}$
 (2023)

12. Which are the non-benzenoid aromatic compounds in the following?



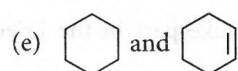
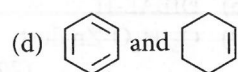
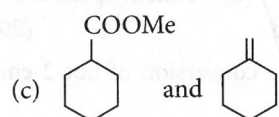
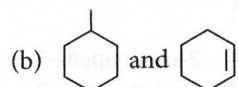
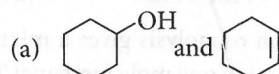
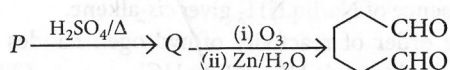
- (a) (iii) and (iv) (b) (i) and (iv)
(c) (ii) and (iv) (d) (i) and (iv)
(e) (ii) and (iii) (2023)

13. What are the products of the following reactions?



- (a) (i) $\text{CH}_3 - \text{CH}_3$ and (ii) $\text{CH}_2 = \text{CH}_2$
(b) (i) $\text{CH}_3 - \text{CH}_2 - \text{CH}_3$ and (ii) $\text{CH}_3 - \text{CH}_3$
(c) (i) $\text{CH}_3 - \text{CH}_2 - \text{CH}_3$ and (ii) CH_4
(d) (i) $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$ and (ii) $\text{H} - \text{C} \equiv \text{C} - \text{H}$
(e) (i) $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$ and (ii) CH_4 (2023)

14. Find the compounds P and Q in the following reactions:



15. Match the following:

- (A) Alkane (i) Phenol
(B) Alicyclic compound (ii) Tropolone
(C) Benzenoid aromatic compound (iii) Isobutane
(D) Non-benzenoid aromatic compound (iv) Furan
(E) Heterocyclic compound (v) Cyclohexene
Choose the correct option.

- (a) (A)-(iii); (B)-(i); (C)-(v); (D)-(ii); (E)-(iv)
(b) (A)-(iii); (B)-(v); (C)-(i); (D)-(ii); (E)-(iv)
(c) (A)-(i); (B)-(ii); (C)-(iii); (D)-(iv); (E)-(v)
(d) (A)-(iii); (B)-(v); (C)-(i); (D)-(iv); (E)-(ii)
(e) (A)-(iii); (B)-(ii); (C)-(i); (D)-(v); (E)-(iv) (2022)

16. Which one of the following molecules contains only primary and tertiary carbon atoms?

- (a) 2, 2-Dimethylbutane (b) 3-Methylpentane
(c) 2, 3-Dimethylbutane (d) *n*-Hexane
(e) 2-Methylhexane (2022)

17. Calculate the number of σ and π bonds in 2-*n*-propylpent-1-ene.

- (a) 22σ bonds, 2π bonds (b) 23σ bonds, 1π bond
(c) 21σ bonds, 1π bond (d) 23σ bonds, 2π bonds
(e) 20σ bonds, 1π bond (2022)

18. Which one of the following molecules gives four isomeric monochlorides on photochemical chlorination?

- (a) 2-Methylpropane (b) *n*-Butane
(c) 2-Methylbutane (d) 2,3-Dimethylbutane
(e) Propane (2022)

19. The products obtained by the ozonolysis of 2-methylbut-1-ene are

- (a) propanone and ethanal
(b) propanone and methanal
(c) butanone and methanal
(d) ethanal and propanal
(e) butanone and methanol. (2020)

20. The catalyst used in the Wacker process of oxidation of ethyne to ethanal is

- (a) Silver (b) Nickel
(c) PdCl_2 (d) V_2O_5
(e) Ziegler catalyst. (2020)

21. Which one of the following is not an isomer of 3-methylbut-1-yne?

- (a) 2,3-Dimethylbuta-1,3-diene
(b) Pent-1-yne
(c) Pent-2-yne
(d) Penta-1,3-diene
(e) 2-Methylbuta-1,3-diene (2020)

22. Which one of the following is a benzenoid aromatic compound?

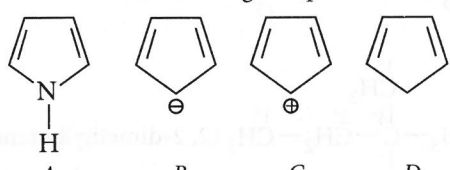
- (a) Cyclooctatetraene (b) Hexyne
(c) Cyclohexane (d) Toluene
(e) Cyclopentadiene (2020)

23. The correct IUPAC name for methylisopropylacetylene is

- (a) 2-methyl-4-pentyne
(b) 4-methyl-2-pentyne
(c) isopropylmethylacetylene
(d) 3-methyl-4-pentyne
(e) 2-methyl-3-pentyne. (2019)

24. The compounds pyridine and planar cyclooctatetraene are _____ respectively.

- (a) aromatic and non-aromatic
(b) aromatic and anti-aromatic
(c) aromatic and aromatic
(d) anti-aromatic and non-aromatic
(e) anti-aromatic and anti-aromatic (2019)

25. Propylene on treatment with $\text{HBr}/\text{H}_2\text{O}_2$ provides
 (a) 1-bromopropane (b) 2-bromopropane
 (c) 1, 2-dibromopropane (d) 1-bromopropan-2-ol
 (e) 2-bromopropan-1-ol. (2019)
26. Sulphonation of benzene with excess sulphuric acid provides
 (a) benzenesulphonic acid
 (b) *p*-benzenedisulphonic acid
 (c) *o*-benzenedisulphonic acid
 (d) *m*-benzenedisulphonic acid
 (e) decomposition of benzene. (2019)
27. Number of constitutional isomers of alkane with formula C_6H_{14} is
 (a) 3 (b) 2 (c) 5 (d) 10
 (e) 8 (2018)
28. Phenylacetylene on treatment with $\text{HgSO}_4/\text{H}_2\text{SO}_4$, H_2O produces
 (a) acetophenone
 (b) phenylacetaldehyde
 (c) phenylacetic acid
 (d) 1-phenylethanol
 (e) 2-phenylethanol. (2018)
29. Which of the following compounds are aromatic?

 A B C D
 (a) A, B (b) A, B, C
 (c) B, C (d) B, C, D
 (e) A, B, D (2018)
30. Aromatic electrophilic substitution reaction that is reversible is
 (a) nitration (b) chlorination
 (c) sulphonation (d) alkylation
 (e) acylation. (2018)
31. The reaction of propene with HBr in presence of peroxide proceeds through the intermediate
 (a) $\text{H}_3\text{C}-\dot{\text{C}}\text{H}-\text{CH}_3$
 (b) $\text{H}_3\text{C}-\dot{\text{C}}\text{H}-\text{CH}_2\text{Br}$

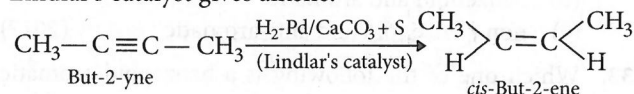
 (c) $\text{H}_3\text{C}-\text{CH}(\text{Br})-\dot{\text{C}}\text{H}_2$
 (d) $\text{H}_3\text{C}-\text{CH}_2-\dot{\text{C}}\text{H}_2$
 (e) none of the above. (2017)
32. Cycloheptatrienyl cation is
 (a) non-benzenoid and non-aromatic
 (b) non-benzenoid and aromatic
 (c) benzenoid and non-aromatic
 (d) benzenoid and aromatic
 (e) non-benzenoid and anti-aromatic. (2017)
33. Which one of the following is a benzenoid aromatic compound?
 (a) Furan
 (b) Thiophene
 (c) Pyridine
 (d) Aniline
 (e) Cyclopentadienyl anion (2016)
34. The major product obtained by the addition reaction of HBr to 4-methylpent-1-ene in the presence of peroxide is
 (a) 1-bromo-4-methylpentane
 (b) 4-bromo-2-methylpentane
 (c) 2-bromo-4-methylpentane
 (d) 3-bromo-2-methylpentane
 (e) 2-bromo-2-methylpentane. (2016)
35. The total number of monohalogenated products formed by halogenation of 2,4,4-trimethylhexane is
 (a) 5 (b) 7 (c) 6 (d) 8
 (e) 0 (2016)
36. The number of possible stereoisomers of the compound $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$ is
 (a) 2 (b) 4 (c) 3 (d) 5
 (e) 6 (2016)
37. The IUPAC name of $(\text{CH}_3)_3\text{C}-\text{CH}=\text{CH}_2$ is
 (a) 2, 2-dimethylbut-3-ene
 (b) 2, 2-dimethylpent-3-ene
 (c) 3,3-dimethylbut-1-ene
 (d) hex-1-ene
 (e) 2, 2-dimethylhex-2-ene. (2015)
38. Isomers which can be interconverted through rotation about $\text{C}-\text{C}$ single bond are
 (a) diastereomers (b) enantiomers
 (c) conformers (d) chain isomers
 (e) position isomers. (2015)
39. Which one of the following compounds shows *cis-trans* isomerism?
 (a) Pent-1-ene (b) But-2-ene
 (c) But-1-ene (d) Propene
 (e) Ethene (2015)

Answer Keys

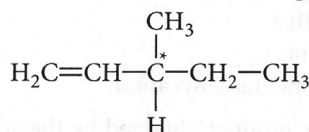
1. (e) 2. (c) 3. (d) 4. (c) 5. (c) 6. (d) 7. (c) 8. (c) 9. (d) 10. (d)
 11. (b) 12. (a) 13. (e) 14. (a) 15. (b) 16. (c) 17. (b) 18. (c) 19. (c) 20. (c)
 21. (a) 22. (d) 23. (b) 24. (b) 25. (a) 26. (d) 27. (c) 28. (a) 29. (a) 30. (c)
 31. (b) 32. (b) 33. (d) 34. (a) 35. (c) 36. (a) 37. (c) 38. (c) 39. (b)

Hints & Explanations

1. (e) : Alkynes on partial reduction in the presence of Lindlar's catalyst gives alkene.

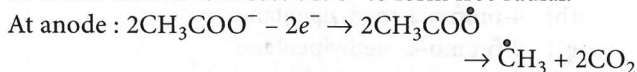


2. (c) : 3-methyl-1-pentene has four different groups attached to one chiral carbon, thus exhibit optical isomerism.

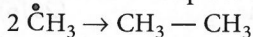


3. (d) : Kolbe's electrolytic method is used to prepare alkane with even number of C-atoms at the anode.

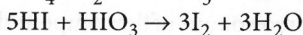
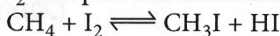
At anode acetate ion loses the e^- to form free radical.



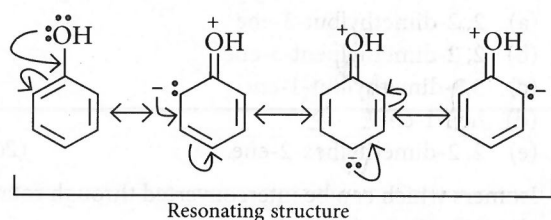
Oxidation takes place by the loss of electrons.



4. (c) : Iodination of methane takes place in presence of HIO_3 as oxidising agent because HIO_3 oxidises HI to form I_2 that prevents backward reaction.

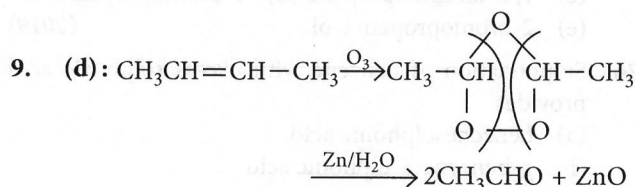
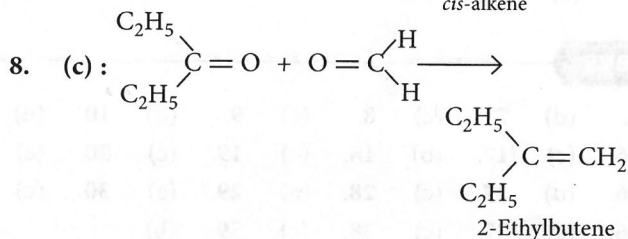
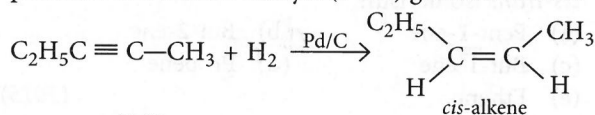


5. (c) : Phenol is most reactive in aromatic electrophilic substitution reaction. As $-\text{OH}$ group is electron donating group, hence it increase e^- density of *o*- and *p*-position that facilitate electrophilic attack.

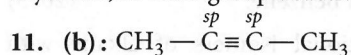


6. (d) : Ozonolysis is the reaction of alkene with ozone in presence of $\text{Zn} - \text{H}_2\text{O}$ to give aldehyde or ketone. This reaction helps in determining position of double bond.

7. (c) : Hydrogenation of unsymmetric alkyne in presence of Lindlar's catalyst (Pd/C) gives *cis*-alkene.



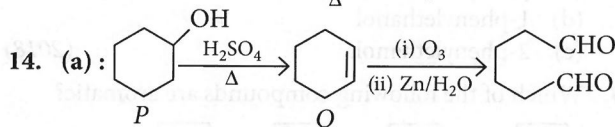
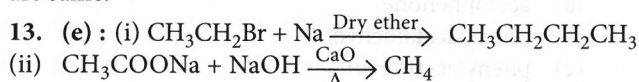
10. (d) : Nitrobenzene does not take part in Friedel-Crafts acylation, as nitro group deactivate the benzene ring.



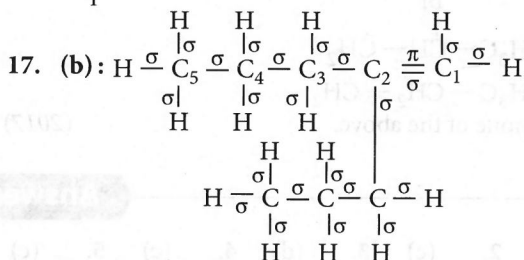
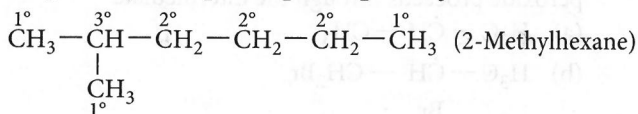
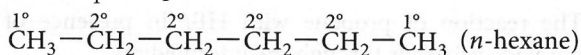
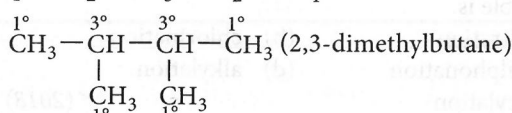
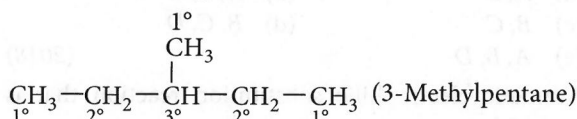
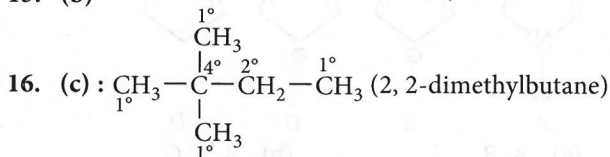
12. (a) : Compounds which do not contain benzene ring and are aromatic in nature are called non-benzenoid aromatic compounds.

(iii) and (iv) are non-benzenoid aromatic compounds.

Note : In the given question, both the options (b) and (d) are same.



15. (b)

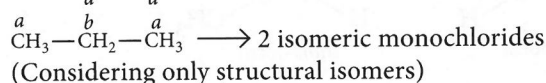
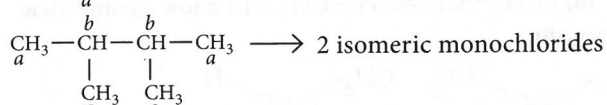
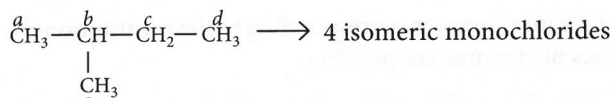
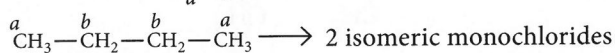
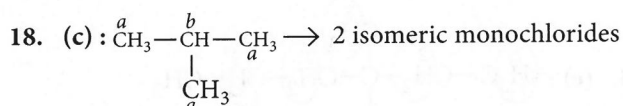


C—C $\Rightarrow$ 7 σ bonds

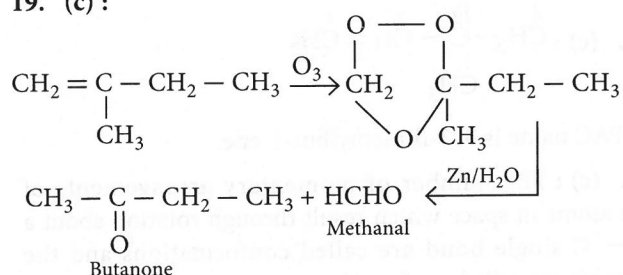
C—H $\Rightarrow$ 16 σ bonds

C=C $\Rightarrow$ 1 π bond

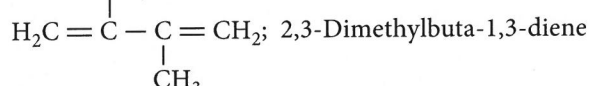
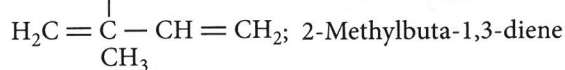
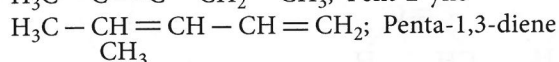
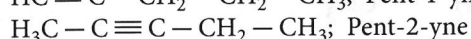
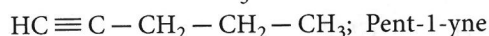
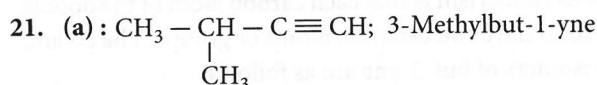
Total 23 σ bonds and one π bond are present.



19. (c):

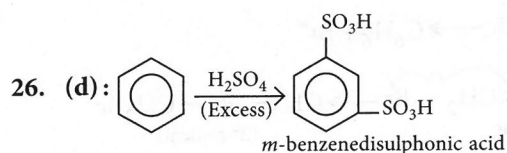
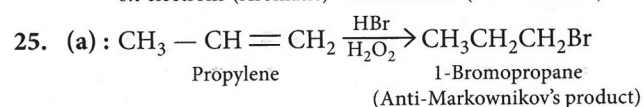
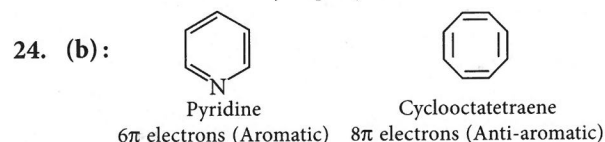
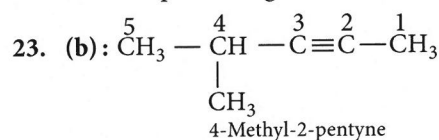


20. (c): The catalyst used in Wacker process of oxidation of ethyne to ethanal is PdCl_2 .

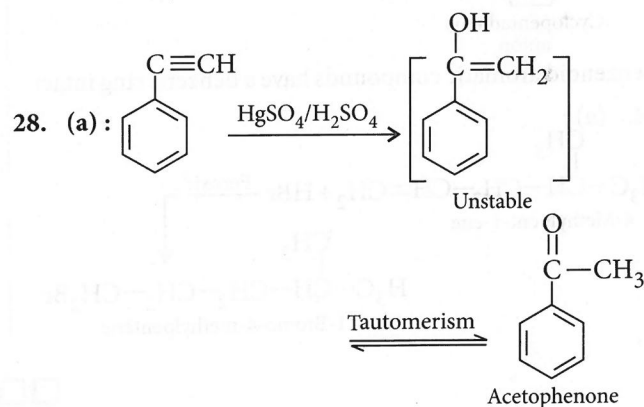
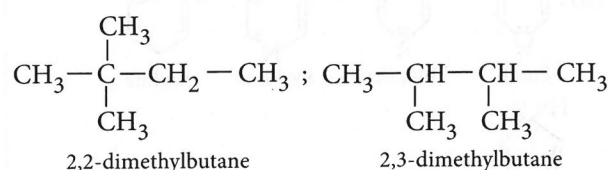
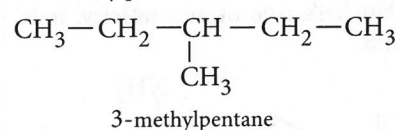
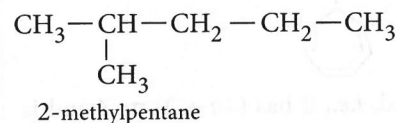
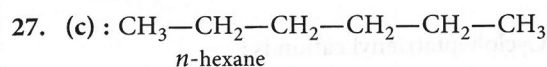


Hence, 2,3-dimethylbuta-1,3-diene is not an isomer of 3-methylbut-1-yne.

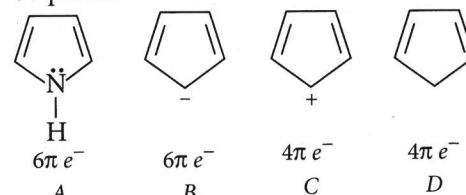
22. (d): Aromatic compounds which contain one or more benzene rings in their structure are called benzenoid aromatic compounds e.g., toluene.



Sulphonate group ($-\text{SO}_3\text{H}$) is a ring deactivating, *meta*-directing group for further electrophilic aromatic substitution.

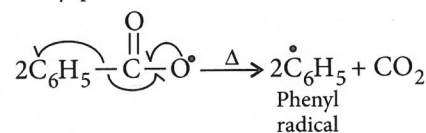
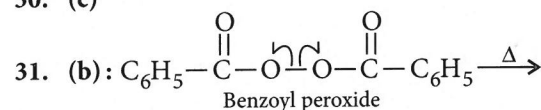


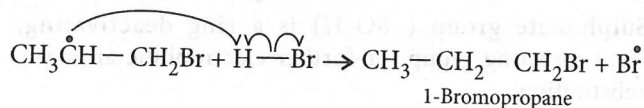
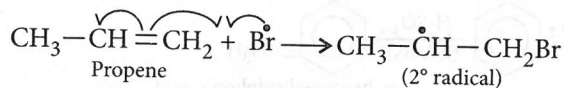
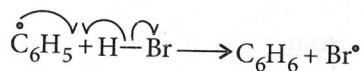
29. (a): According to Huckel rule, for a compound to be aromatic, it should contain $(4n+2)\pi$ electrons and should be planar.



Thus, A and B are aromatic.

30. (c)

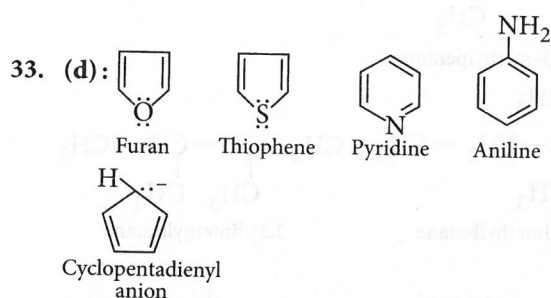




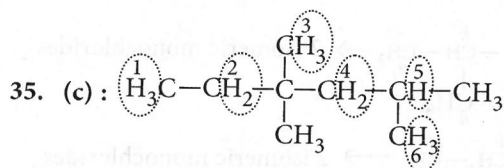
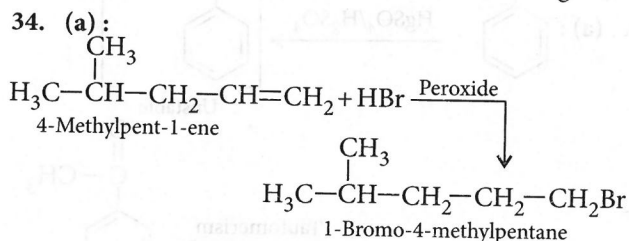
32. (b): Cycloheptatrienyl cation is :



It is aromatic compound, i.e., it has $(4n + 2) \pi e^-$ s and is planar. Then, it obeys Huckel's rule of aromaticity. It is non-benzenoid compound.

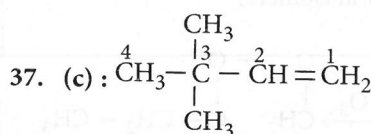
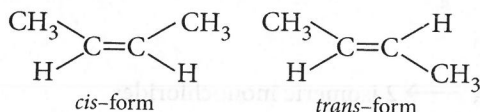


Benzenoid aromatic compounds have a benzene ring intact.



Six structural isomers corresponding to the substitution of 6 types of H atoms are possible.

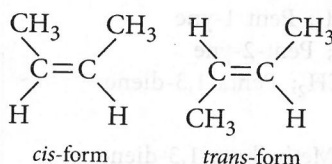
36. (a): $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$ will show geometrical isomerism.



IUPAC name is 3, 3-dimethylbut-1-ene.

38. (c): The number of momentary arrangements of the atoms in space which result through rotation about a C — C single bond are called conformations and the isomers are called conformers.

39. (b): The necessary condition for a molecule to exhibit *cis-trans* isomerism is that each carbon atom of the double bond must have two different atoms or groups. The *cis* and *trans* isomers of but-2-ene are as follows:



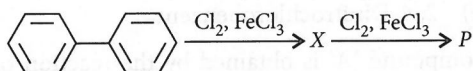
Haloalkanes and Haloarenes

- The following reaction is known as $\text{CH}_3\text{Br} + \text{AgF} \longrightarrow \text{CH}_3\text{F} + \text{AgBr}$
 - Finkelstein reaction
 - Wurtz reaction
 - Sandmeyer's reaction
 - Williamson reaction
 - Swarts reaction. (2024)
- Which one of the following compounds can exhibit both optical isomerism and geometrical isomerism?
 - 2-chloropent-2-ene
 - 5-chloropent-2-ene
 - 4-chloropent-2-ene
 - 3-chloropent-1-ene
 - 3-chloropent-2-ene (2024)
- Choose the achiral molecule in the following:
 - 2-Bromobutane
 - 3-Nitropentane
 - 3-Chlorobut-1-ene
 - 1-Bromoethanol
 - 2-Hydroxypropanoic acid (2024)
- The reagents and conditions (X) required for the following conversion

 - $X = \text{H}_2\text{O}$, 623 K, 300 atm and H^+
 - $X = \text{KOH}$, 443 K, 100 atm and H^+
 - $X = \text{NaOH}$, 368 K, 300 atm and H^+
 - $X = \text{warm, H}_2\text{O}$ and H^+
 - $X = \text{NaOH}$, 623 K, 300 atm and H^+ (2024)
- Which of the following statement is incorrect?
 - (-)-2-bromooctane reacts with NaOH gives (+)-octan-2-ol by $\text{S}_{\text{N}}2$ reaction.
 - 2-Bromobutane reacts with NaOH gives racemic mixture by $\text{S}_{\text{N}}1$ reaction.
 - β -elimination of 2-bromopentane gives pent-1-ene as major product.
 - The hybridization of the carbon in the intermediate formed in $\text{S}_{\text{N}}1$ reaction is sp^2 .
 - Primary alkyl halide undergoes $\text{S}_{\text{N}}2$ faster than secondary alkyl halide. (2024)
- A tertiary alkyl halide (X), $\text{C}_4\text{H}_9\text{Br}$, reacted with alc. KOH to give compound (Y). Compound (Y) reacted with HBr in presence of peroxide to give compound (Z). The compounds (Y) and (Z) are respectively
 - propene and tert.butylbromide
 - 2-methyl-1-propene and 1-bromo-2 methylpropane
 - but-1-ene and 2-bromopropane
 - but-2-ene and 2-methylpropane
 - but-2-ene and 3-methylpropane (2024)
- What is the major product in the following reaction?

$$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH}_2 + \text{HBr} \longrightarrow$$
 - $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{Br}$
 - $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$
 - $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \underset{\text{Br}}{\underset{\text{Br}}{\text{C}}} - \text{CH}_3$
 - $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \underset{\text{Br}}{\text{CH}} - \text{CH}_2 - \text{Br}$
 - $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$ (2023)
- Which of the following compounds is used as refrigerant?
 - CCl_2F_2
 - $\text{ClCH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{Cl}$
 - CCl_4
 - CCl_3NO_2
 - COCl_2 (2022)
- Which of the following aryl chlorides on warming with water forms the corresponding phenol?
 - 4-Methylchlorobenzene
 - 4-Nitrochlorobenzene
 - 2, 4, 6-Trinitrochlorobenzene
 - 2-Nitrochlorobenzene
 - 2, 4-Dinitrochlorobenzene (2022)
- Compound 'A' is obtained by the reaction of benzyl chloride with magnesium metal in dry ether followed by treatment with water. What is the compound 'A'?
 - Toluene
 - Benzyl alcohol
 - Phenol
 - Benzene
 - Benzaldehyde (2021)

11. The compound that does not undergo hydrolysis by S_N1 mechanism is
 (a) $C_6H_5CH_2Cl$ (b) $C_6H_5CH(CH_3)Cl$
 (c) C_6H_5Cl (d) CH_3CH_2Cl
 (e) $C_6H_5CH(C_6H_5)Cl$ (2020)
12. The neopentyl halide in ethanol yields alkenes by $E1$ mechanism due to
 (a) low concentration of solvent
 (b) absence of base
 (c) it is a primary halide
 (d) steric factor which prevents $E2$ mechanism
 (e) solvation effect. (2019)
13. Aryl bromides are not good candidates for
 (a) Wurtz-Fittig reaction
 (b) Fittig reaction
 (c) Friedel-Crafts reaction
 (d) Grignard reaction
 (e) Gabriel-phthalimide synthesis. (2019)
14. Which one of the following statements is false?
 (a) R and S configurations correspond to the enantiomers of an optically active compound.
 (b) The process of converting an optically active compound into a racemate is called racemization.
 (c) A molecule containing a plane of symmetry can be optically active.
 (d) Optical isomers that are not enantiomers are called diastereoisomers.
 (e) All chiral objects are asymmetric. (2018)
15. Neopentyl bromide undergoes dehydrohalogenation to give alkenes even though it has no β -hydrogen. This is due to
 (a) $E2$ mechanism
 (b) $E1$ mechanism
 (c) rearrangement of carbocations by $E1$ mechanism
 (d) $E1cB$ mechanism
 (e) $E1$ mechanism. (2018)
16. The compound which does not lead to nitrile by substitution with $NaCN/DMSO$ is
 (a) benzyl chloride
 (b) ethyl chloride
 (c) *iso*-propyl chloride
 (d) chlorobenzene
 (e) *iso*-butyl chloride. (2018)
17. The major product P formed in the following reaction is



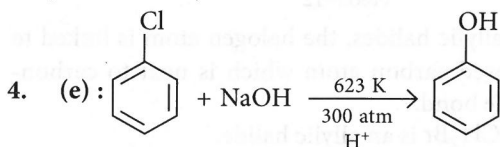
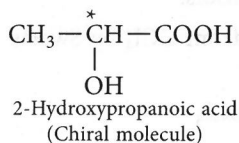
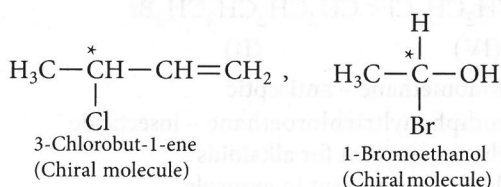
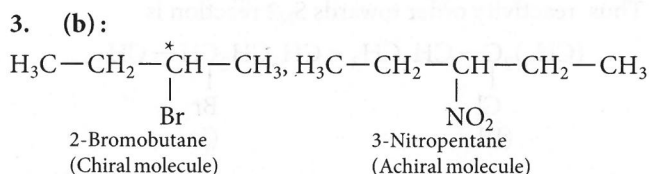
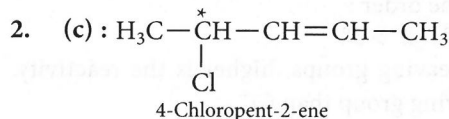
- (a)
- (b)
- (c)
- (d)
- (e) (2017)
18. The correct order of increasing reactivity of the following alkyl halides, $CH_3CH_2CH(Br)CH_3$ (I), $CH_3CH_2CH_2CH_2Br$ (II), $(CH_3)_2CClCH_2CH_3$ (III) and $CH_3CH_2CH_2Cl$ (IV), towards S_N2 displacement is
 (a) $I < II < III < IV$ (b) $III < I < IV < II$
 (c) $III < I < II < IV$ (d) $II < IV < I < III$
 (e) $I < III < II < IV$ (2017)
19. Some organic compounds are given in List I and their uses in List II. Choose the correct matching.
- | List I | List II |
|---|-----------------------------|
| (A) Triiodomethane | (i) solvent for alkaloids |
| (B) <i>p, p'</i> -Dichlorodiphenyltrichloroethane | (ii) propellant in aerosols |
| (C) Trichloromethane | (iii) antiseptic |
| (D) Dichloromethane | (iv) insecticide |
- (a) (A) - (ii), (B) - (iv), (C) - (i), (D) - (iii)
 (b) (A) - (iii), (B) - (iv), (C) - (i), (D) - (ii)
 (c) (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii)
 (d) (A) - (iii), (B) - (i), (C) - (iv), (D) - (ii)
 (e) (A) - (i), (B) - (iii), (C) - (ii), (D) - (iv) (2016)
20. Freon-12 is manufactured from CCl_4 by
 (a) Wurtz reaction (b) Swarts reaction
 (c) Fittig reaction (d) Wurtz-Fittig reaction
 (e) Sandmeyer reaction. (2016)
21. Which one of the following is an allylic halide?
 (a) 2-Chlorobutane
 (b) Chloroethene
 (c) 3-Bromopropene
 (d) 2-Chlorotoluene
 (e) Dichloromethane (2015)

Answer Keys

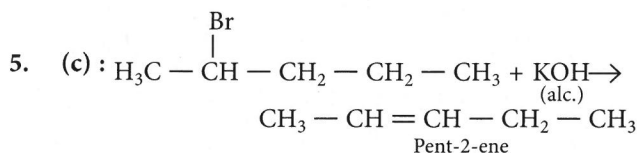
1. (e) 2. (c) 3. (b) 4. (e) 5. (c) 6. (b) 7. (b) 8. (a) 9. (c) 10. (a)
 11. (c) 12. (d) 13. (e) 14. (c) 15. (c) 16. (d) 17. (b) 18. (b) 19. (b) 20. (b)
 21. (c)

Hints & Explanations

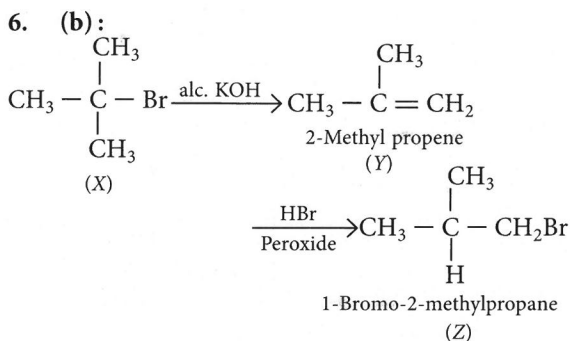
1. (e): The synthesis of alkyl fluorides is best accomplished by heating an alkyl chloride/bromide in the presence of a metallic fluoride such as AgF, Hg₂F₂, CoF₂ or SbF₃. The reaction is termed as Swarts reaction.



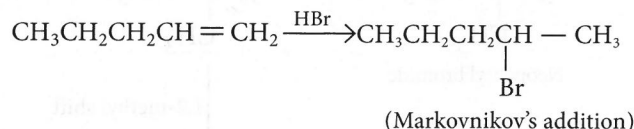
Haloarenes are very less reactive towards nucleophilic substitution reaction due to partial double bond character in C—Cl bond because of resonance, which makes it difficult to break.



Saytzeff rule states that favoured product in dehydrohalogenation reaction is the alkene with the greatest amount of alkyl group connected to the doubly bonded carbon atoms.



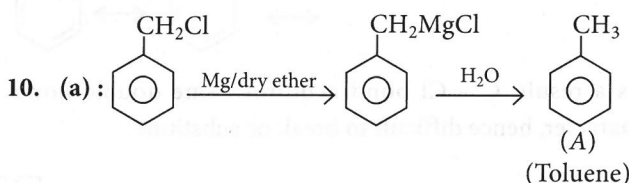
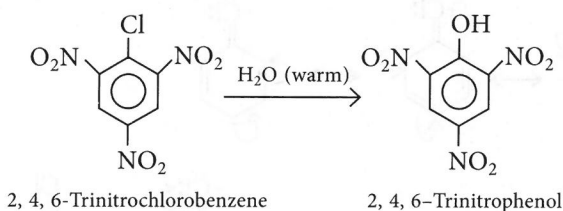
7. (b):



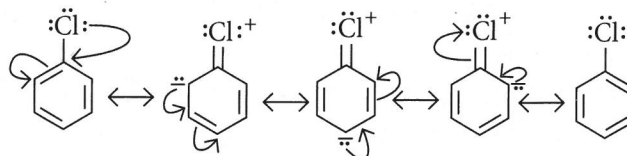
8. (a): CCl₂F₂ (Freon-12), Chlorofluorocarbon, is used as refrigerant.

9. (c): In chlorobenzene, C—Cl bond has partial double bond character due to resonance.

Due to the presence of electron withdrawing group, C—Cl bond weakens hence it becomes easier to undergo nucleophilic substitution reactions. Due to the presence of three —NO₂ groups (having —M effect), 2,4,6-trinitrochlorobenzene undergoes nucleophilic substitution easily.



11. (c): The electron pair on chlorine atom is in conjugation with the electrons of the benzene ring which results in the following resonating structures.



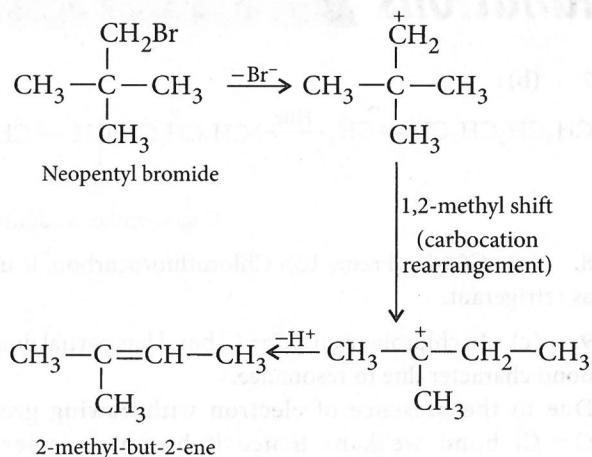
This results in delocalisation of the electrons of C—Cl bond and a partial double bond character is developed in the chlorobenzene, which makes it difficult for the nucleophile to cleave the C—Cl bond.

12. (d)

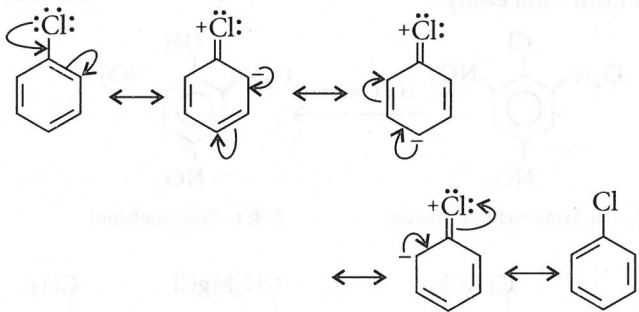
13. (e): Aryl halides do not undergo nucleophilic substitution (i.e., cleavage of C—Cl bond in haloarenes is quite difficult) with potassium phthalimide under ordinary conditions hence, aryl bromides are not good candidates for Gabriel-phthalimide synthesis.

14. (c): A molecule containing plane of symmetry cannot be optically active.

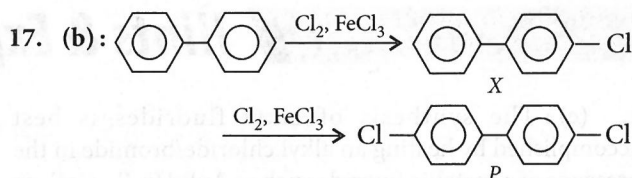
15. (c) :



16. (d) : In chlorobenzene, the lone pairs of electron on the chlorine atom are delocalised on the benzene ring as shown :



As a result, C - Cl bond acquires some double bond character, hence difficult to break or substitute.

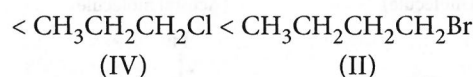
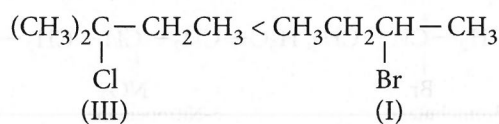


18. (b) : Reactivity order of alkyl halides towards $\text{S}_\text{N}2$ reaction follows the order :

Methyl halide $> 1^\circ > 2^\circ > 3^\circ$

Also, better the leaving groups, higher is the reactivity. Br^- is a better leaving group than Cl^- .

Thus, reactivity order towards $\text{S}_\text{N}2$ reaction is



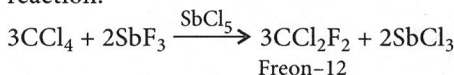
19. (b) : Triiodomethane - antiseptic

p, p'-Dichlorodiphenyltrichloroethane - insecticide

Trichloromethane - solvent for alkaloids

Dichloromethane - propellant in aerosols.

20. (b) : Freon-12 is manufactured from CCl_4 by Swarts reaction.



21. (c) : In allylic halides, the halogen atom is linked to a sp^3 -hybridised carbon atom which is next to carbon-carbon double bond.

$\text{CH}_2=\text{CH}-\text{CH}_2\text{Br}$ is an allylic halide.



Alcohols, Phenols and Ethers

- Which of the following explains why dimethyl ether has lower boiling point than its isomeric compound, ethanol?
 - Resonance
 - London dispersion forces
 - Hybridisation
 - van der Waals forces
 - Hydrogen bonding (2024)
- Which of the following cannot be prepared by the reduction of either a ketone or an aldehyde with NaBH_4 in methanol?
 - 2-Butanol
 - 2-Methyl 2-propanol
 - 2-Methyl 1-propanol
 - 1-Butanol
 - 2-Phenylethanol (2024)
- Which is incorrect statement with regard to 1-phenylethanol?
 - It is a primary alcohol
 - It is an aromatic alcohol.
 - It forms a ketone on oxidation.
 - It is optically active.
 - It liberates H_2 when treated with metallic sodium. (2024)
- Phenol can be converted to salicylaldehyde by
 - Kolbe reaction
 - Williamson reaction
 - Etard reaction
 - Reimer-Tiemann reaction
 - Stephen reaction. (2024)
- Compound 'X' ($\text{C}_6\text{H}_6\text{O}$) reacts with aqueous NaOH to give compound 'Y'. 'Y' reacts with CO_2 followed by acidification to give compound 'Z'. The compounds X, Y and Z are respectively
 - benzene, phenol, salicylaldehyde
 - phenol, benzene, benzoic acid
 - phenol, sodium phenoxide, benzophenone
 - benzaldehyde, sodium phenoxide, salicylic acid
 - phenol, sodium phenoxide, salicylic acid (2024)
- Which of the following statement is correct?
 - Bromination of phenol in CS_2 at low temperature give 2,4,6-tribromophenol.
 - Oxidation of phenol with chromic acid gives benzene.
 - Conversion of phenol into tribromophenol by bromine water is a nucleophilic substitution reaction.
 - p*-Nitrophenol is steam volatile due to intermolecular hydrogen bonding.
 - The intermediate in Reimer-Tiemann reaction is substituted benzal chloride. (2024)
- The major products formed when one mole of $\text{CH}_3 - \text{CH}_2 - \text{CH}(\text{CH}_3) - \text{CH}_2 - \text{O} - \text{CH}_2 - \text{CH}_3$ is treated with one mole of HI are
 - 2-methylbutan-1-ol and iodoethane
 - ethanol and 2-methyliodobutane
 - 2-methylbutan-2-ol and iodoethane
 - 2-methylbutan-2-ol and iodomethane
 - 2-methylbutan-1-ol and ethene (2024)
- Resorcinol is
 - benzene-1, 3-diol
 - benzene-1, 4-diol
 - benzene-1, 2-diol
 - 3-methylphenol
 - 4-methylphenol. (2022)
- Choose the correct order of acidity of the following phenols :

(I) <i>m</i> -nitrophenol	(II) <i>p</i> -cresol
(III) <i>p</i> -nitrophenol	(IV) phenol

 - (III) > (I) > (IV) > (II)
 - (II) > (IV) > (III) > (I)
 - (I) > (II) > (III) > (IV)
 - (IV) > (II) > (III) > (I)
 - (III) > (II) > (I) > (IV) (2022)
- Oxidation of 1° alcohols to aldehydes is very successful for the alcohols like
 - pent-2-yn-1-ol
 - 1-hexanol
 - n*-propyl alcohol
 - 1-pentanol
 - 1-octanol. (2018)
- The halogen compound which will not react with phenol to give ethers is
 - ethyl chloride
 - methyl chloride
 - benzyl chloride
 - vinyl chloride
 - allyl chloride. (2018)
- Number of acyclic structural isomers of the compound having the molecular formula $\text{C}_4\text{H}_{10}\text{O}$ is
 - 4
 - 5
 - 6
 - 7
 - 3 (2016)

13. 375 mg of an alcohol reacts with required amount of methyl magnesium bromide and releases 140 mL of methane gas at STP. The alcohol is

- (a) ethanol (b) *n*-butanol
(c) methanol (d) *n*-propanol
(e) phenol.

(2016)

14. Out of the following isomeric alcohols containing five carbon atoms, the alcohol that exhibits optical isomerism is

- (a) 1-pentanol (b) 2-pentanol
(c) 3-pentanol (d) 2-methyl-2-butanol
(e) 2, 2-dimethyl-1-propanol.

(2015)

Answer Keys

1. (e) 2. (b) 3. (a) 4. (d) 5. (e) 6. (e) 7. (a) 8. (a) 9. (a) 10. (e)
11. (d) 12. (d) 13. (d) 14. (b)

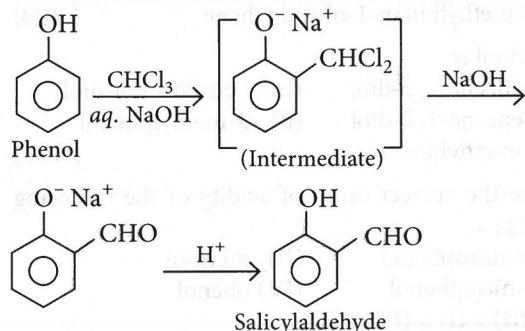
Hints & Explanations

1. (e): The high boiling points of alcohols are mainly due to the presence of intermolecular hydrogen bonding which is absent in case of ethers and hydrocarbons.

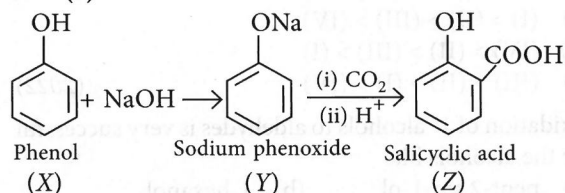
2. (b): On treatment with sodium borohydride (NaBH_4) aldehydes yield primary alcohols whereas ketones give secondary alcohols. So, 2-methyl-2-propanol cannot be prepared by this method as it is a tertiary alcohol.

3. (a): 1-phenylethanol is a secondary alcohol.

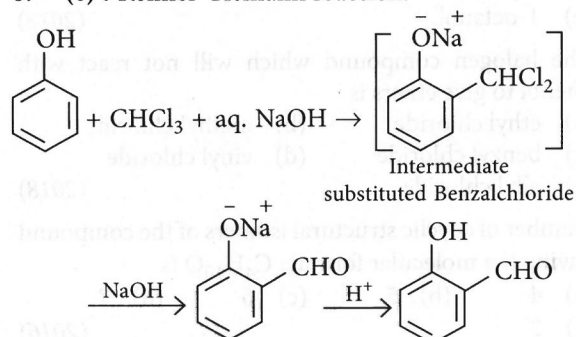
4. (d): On treating phenol with chloroform in the presence of sodium hydroxide, salicylaldehyde is produced. This reaction is known as Reimer-Tiemann reaction.



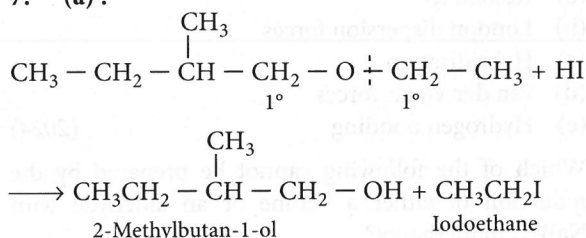
5. (e):



6. (e): Reimer-Tiemann reaction.



7. (a):

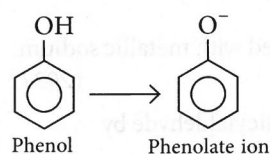


I^- will attack less substituted carbon.

8. (a):

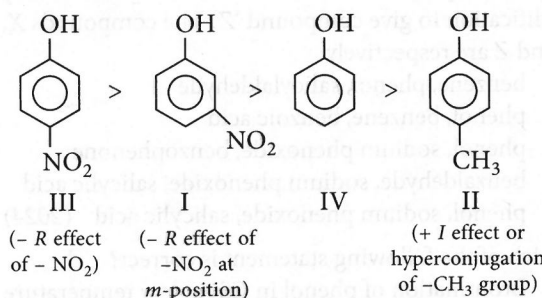


9. (a): Phenol undergoes dissociation as

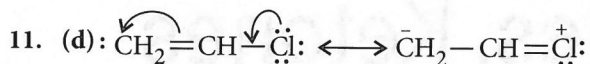


The presence of electron withdrawing group on benzene ring increases the stability of phenolate ions thus, increases the acidity of phenol. While electron donating group decreases stability of phenolate ion as well as the acidity of phenol.

So, the correct order of acidic strength is

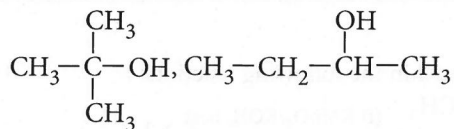
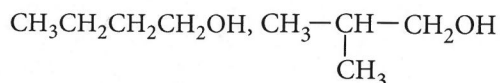


10. (e): Long chain alcohols are oxidised to aldehydes, most likely, which is a key reaction in the manufacture of perfumes.

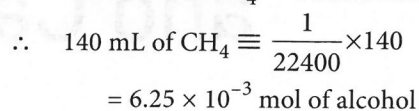
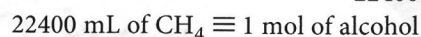
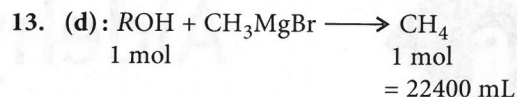
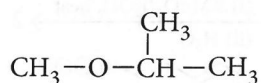
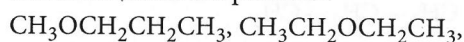


Thus, C—Cl bond acquires partial double bond character and will not undergo substitution.

12. (d): Four alcohols are possible :



and three ethers are possible :

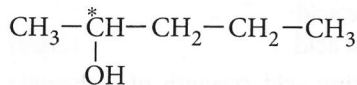


Now, $n = \frac{w}{M}$

$\Rightarrow \text{Molecular mass of alcohol} = \frac{w}{n} = \frac{375 \times 10^{-3}}{6.25 \times 10^{-3}}$
 $= 60 \text{ g mol}^{-1}$

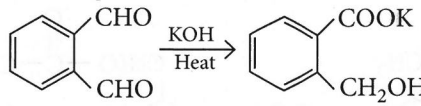
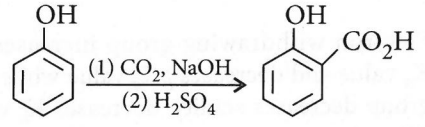
Hence, the alcohol is *n*-propanol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$).

14. (b): 2-Pentanol contains an asymmetric carbon atom and is optically active.



Aldehydes, Ketones and Carboxylic Acids

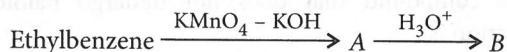
- Which of the following carboxylic acid has the highest pK_a ?
 (a) Ethanoic acid
 (b) Chloroethanoic acid
 (c) Fluoroethanoic acid
 (d) Dichloroethanoic acid
 (e) Trifluoroethanoic acid
 (2024)
- The order of decreasing acid strength of carboxylic acids is
 (a) $FCH_2COOH > ClCH_2COOH > NO_2CH_2COOH > CNCH_2COOH$
 (b) $CNCH_2COOH > FCH_2COOH > NO_2CH_2COOH > ClCH_2COOH$
 (c) $NO_2CH_2COOH > FCH_2COOH > ClCH_2COOH > CNCH_2COOH$
 (d) $FCH_2COOH > NO_2CH_2COOH > ClCH_2COOH > CNCH_2COOH$
 (e) $NO_2CH_2COOH > CNCH_2COOH > FCH_2COOH > ClCH_2COOH$
 (2024)
- An organic compound $X(C_6H_6O)$ on reaction with zinc dust gives 'Y'. The product 'Y' reacts CH_3COCl in presence of anhydrous $AlCl_3$ to give 'Z' (C_9H_8O). The compounds X, Y and Z are respectively
 (a) benzaldehyde, benzene, methyl phenyl ketone
 (b) phenol, benzene, acetophenone
 (c) phenol, naphthalene, acetophenone
 (d) benzene, phenol, diphenyl ketone
 (e) cyclohexanol, cyclohexane, benzophenone.
 (2024)
- On heating an aldehyde with Fehling's reagent, a reddish-brown precipitate is obtained due to the formation of
 (a) cupric oxide
 (b) cuprous oxide
 (c) carboxylic acid
 (d) silver
 (e) copper acetate.
 (2024)
- The increasing order of acid strength of the following carboxylic acids is
 (i) $(CH_3)_3C - COOH$ (ii) $(CH_3)_2CH - COOH$
 (iii) CH_3CH_2COOH
 (a) (ii) < (i) < (iii)
 (b) (i) < (iii) < (ii)
 (c) (ii) < (iii) < (i)
 (d) (iii) < (ii) < (i)
 (e) (i) < (ii) < (iii)
 (2024)
- Identify 1 and 2 in the following reactions :
 A. $\text{C}_6\text{H}_5\text{CH}_3 \xrightarrow[\text{(ii) H}_3\text{O}^+]{\text{(i) KMnO}_4/\text{KOH, heat}} 1$
 B. $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{CH}_3 \xrightarrow[\text{(ii) H}_3\text{O}^+]{\text{(i) KMnO}_4/\text{KOH, heat}} 2$
 (a) 1. $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ 2. $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$
 (b) 1. $\text{C}_6\text{H}_5\text{OH}$ 2. $\text{C}_6\text{H}_5\text{COOH}$
 (c) 1. C_6H_6 2. $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$
 (d) 1. $\text{C}_6\text{H}_5\text{COOH}$ 2. $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$
 (e) 1 and 2 both $\text{C}_6\text{H}_5\text{COOH}$
 (2023)
- Identify 1 and 2 in the following reaction :
 $CH_3Br + Mg \xrightarrow{\text{Dry ether}} 1 \xrightarrow{\text{H}_3\text{O}^+} 2$
 (a) $H_3C - CH_3$ and $\text{C}_2\text{H}_5\text{OH}$
 (b) CH_3MgBr and CH_3CHO
 (c) CH_3MgBr and $\text{C}_2\text{H}_5\text{OH}$
 (d) CH_4 and CH_3CHO
 (e) $H_3C - CH_3$ and $\text{C}_2\text{H}_5\text{OH}$
 (2023)
- Which one of the following represents valeraldehyde?
 (a) $CH_3CH_2CH_2CH_2CHO$
 (b) $CH_3CH(CH_3)CH_2CHO$
 (c) $CH_3CH(OCH_3)CHO$
 (d) $(CH_3)_2CHCHO$
 (e) $CH_3CH_2CH(CH_3)CHO$
 (2022)
- Toluene on treatment with chromic oxide in acetic anhydride at 273 K to 283 K gives
 (a) benzaldehyde
 (b) benzylidene diacetate
 (c) benzoic acid
 (d) benzyl alcohol
 (e) phenylacetate.
 (2022)

10. A research scholar returned to the laboratory after the lock down due to Covid-19. He kept acetone, benzaldehyde, acetaldehyde and diethyl ketone in four different bottles. The bottles contained only the label as P, Q, R and S. He forget which bottle contained which compound. Compounds P and R only underwent iodoform test. Compound R alone gave reddish brown precipitate with Fehling's reagent. Compound Q and R alone underwent Tollens' test. Compound S did not answer any of the above test. Identify the compounds P, Q, R and S.
(a) P-diethyl ketone ; Q-benzaldehyde ; R-acetaldehyde ; S-acetone
(b) P-acetone ; Q-benzaldehyde ; R-acetaldehyde ; S-diethyl ketone
(c) P-acetone Q-acetaldehyde ; R-benzaldehyde ; S-diethyl ketone
(d) P-acetaldehyde ; Q-acetone ; R-diethyl ketone ; S-benzaldehyde
(e) P-benzaldehyde ; Q-diethyl ketone ; R-acetone ; S-acetaldehyde (2021)
11. The increasing order of acid strength of the following carboxylic acid is
(a) $\text{ClCH}_2 - \text{CH}_2 - \text{COOH} < \text{ClCH}_2\text{COOH} < \text{NC} - \text{CH}_2\text{COOH} < \text{CHCl}_2\text{COOH}$
(b) $\text{ClCH}_2\text{COOH} < \text{NC} - \text{CH}_2\text{COOH} < \text{ClCH}_2\text{CH}_2\text{COOH} < \text{CHCl}_2\text{COOH}$
(c) $\text{ClCH}_2 - \text{CH}_2 - \text{COOH} < \text{CHCl}_2 - \text{COOH} < \text{ClCH}_2 - \text{COOH} < \text{NC} - \text{CH}_2 - \text{COOH}$
(d) $\text{NC} - \text{CH}_2 - \text{COOH} < \text{Cl} - \text{CH}_2\text{COOH} < \text{CHCl}_2\text{COOH} < \text{Cl} - \text{CH}_2\text{CH}_2\text{COOH}$
(e) $\text{ClCH}_2\text{CH}_2 - \text{COOH} < \text{CHCl}_2\text{COOH} < \text{ClCH}_2\text{COOH} < \text{NC} - \text{CH}_2\text{COOH}$ (2021)
12. An organic compound 'A' with molecular formula $\text{C}_7\text{H}_6\text{O}$ forms 2,4-DNP derivative and reduces Tollens' reagent. When 'A' is heated with conc. KOH, it gives sodium benzoate and compound 'B'. The compound 'B' is
(a) benzene (b) toluene
(c) acetophenone (d) benzaldehyde
(e) benzyl alcohol. (2020)
13. Which one of the following compounds would undergo Cannizzaro reaction?
(a) 2-Methylpentanal (b) Cyclohexanone
(c) 2,2-Dimethylbutanal (d) 1-Phenylpropanone
(e) Phenylacetaldehyde (2020)
14. The following reaction is named as

(a) Reimer-Tiemann (b) Kolbe-Schmitt
(c) Cannizzaro (d) Gattermann
(e) Aldol. (2019)
15. When $\text{C}_6\text{H}_5\text{COCOC}_6\text{H}_5$ is reduced with LiAlH_4 , the product formed has _____ stereoisomers.
(a) 2 (b) 3 (c) 4 (d) 6
(e) 8 (2019)
16. The compound which does not lead to benzoic acid by oxidation with KMnO_4 is
(a) toluene (b) benzyl alcohol
(c) n-butylbenzene (d) t-butylbenzene
(e) styrene. (2019)
17. The compound that does not undergo haloform reaction is
(a) acetaldehyde (b) ethanol
(c) acetone (d) acetophenone
(e) propiophenone. (2018)
18. The weakest among the following acids is
(a) peroxyacetic acid (b) acetic acid
(c) chloroacetic acid (d) trichloroacetic acid
(e) propanoic acid. (2018)
19. Name of the following reaction is

(a) Reimer-Tiemann (b) Kolbe-Schmitt
(c) Cannizzaro (d) Gattermann
(e) Gattermann-Koch. (2017)
20. X and Y in the below reaction are _____ and _____, respectively.
 $\text{C}_6\text{H}_5 - \text{CO}_2\text{H} + \text{X} \xrightarrow{\text{heat}} \text{C}_6\text{H}_5 - \text{COCl}$
 $\xrightarrow[\text{quinoline}]{\text{H}_2, \text{Pd/BaSO}_4} \text{Y}$
(a) SOCl_2 and $\text{C}_6\text{H}_5\text{CHO}$
(b) $(\text{COCl})_2$ and $\text{C}_6\text{H}_5\text{CH}_3$
(c) SOCl_2 and $\text{C}_6\text{H}_5\text{CH}_3$
(d) $(\text{COCl})_2$ and $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$
(e) SOCl_2 and $\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$ (2017)
21. The correct increasing order of the acid strength of acids, butyric acid (I), 2-chlorobutyric acid(II), 3-chlorobutyric acid (III), and 2,2-dichlorobutyric acid (IV) is
(a) $\text{I} < \text{II} < \text{III} < \text{IV}$ (b) $\text{III} < \text{II} < \text{IV} < \text{I}$
(c) $\text{I} < \text{III} < \text{II} < \text{IV}$ (d) $\text{III} < \text{I} < \text{II} < \text{IV}$
(e) $\text{IV} < \text{III} < \text{II} < \text{I}$ (2017)
22. The condensation reaction between one equivalent of acetone and two equivalents of benzaldehyde in presence of dilute alkali leads to the formation of
(a) benzalacetophenone
(b) benzylideneacetone
(c) dibenzylideneacetone
(d) benzoic acid and acetic acid
(e) only benzoic acid. (2017)

23. Which one of the following involves nucleophilic addition?

- (a) Kolbe's reaction of phenol
(b) Williamson's synthesis of ethers
(c) Reimer-Tiemann's reaction of phenol
(d) Kolbe's electrolytic synthesis of ethane from sodium acetate
(e) Aldol formation from ethanal (2016)

24. Predict the product (B) in the following sequence of reactions :



- (a) Benzaldehyde (b) Benzophenone
(c) Benzene (d) Acetophenone
(e) Benzoic acid (2016)

25. When methane is heated with dioxygen in the presence of Mo_2O_3 catalyst, the organic product obtained is

- (a) methanal (b) ethanoic acid
(c) methanol (d) ethanol
(e) 2-methylpropan-2-ol. (2015)

26. Which one of the following undergoes iodoform test?

- (a) Propanal (b) Ethanal
(c) Benzophenone (d) Benzaldehyde
(e) Phenol (2015)

Answer Keys

1. (a) 2. (e) 3. (b) 4. (b) 5. (e) 6. (e) 7. (c) 8. (a) 9. (b) 10. (b)
11. (a) 12. (e) 13. (c) 14. (c) 15. (b) 16. (d) 17. (e) 18. (a) 19. (b) 20. (a)
21. (c) 22. (c) 23. (e) 24. (e) 25. (a) 26. (b)

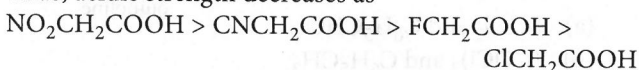
Hints & Explanations

1. (a) : Electron withdrawing group increases acidity, increases K_a value and decreases pK_a value while electron donating group decreases acidity, decreases K_a value and increases pK_a value.

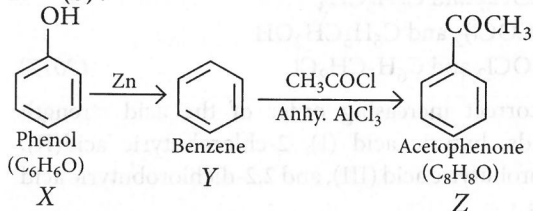
The increasing order of pK_a values is $\text{CF}_3\text{COOH} < \text{CHCl}_2\text{COOH} < \text{FCH}_2\text{COOH} < \text{ClCH}_2\text{COOH} < \text{CH}_3\text{COOH}$.

2. (e) : Acidity of carboxylic acid increases in the presence of electron withdrawing groups and decreases in the presence of electron donating groups. The $-I$ effect of groups in the given carboxylic acids decreases in the order $-\text{NO}_2 > -\text{CN} > -\text{F} > -\text{Cl}$.

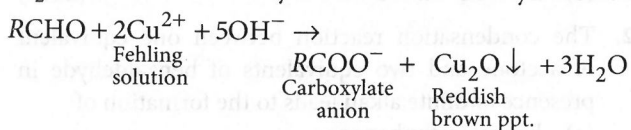
Thus, acidic strength decreases as



3. (b) :

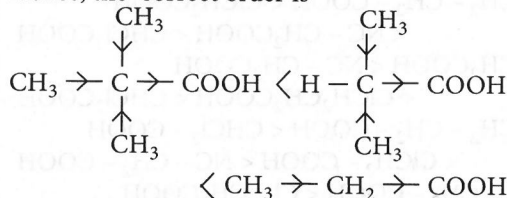


4. (b) : Fehling test of aldehyde : Fehling solution A and B are added to aldehyde, on heating reddish-brown ppt. of Cu_2O will form and aldehyde oxidised to carboxylate anion

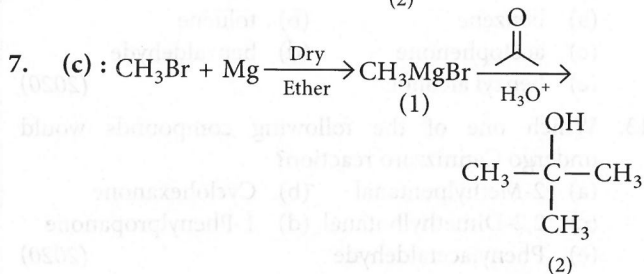
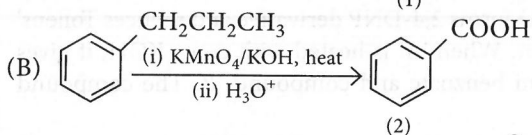
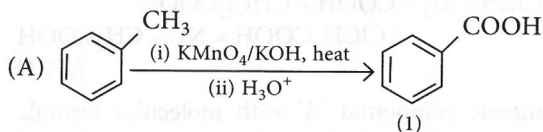


5. (e) : Alkyl groups are electron donating group. Due to inductive effect it pushes e^- density towards through the carboxylate anion, that leads to destability and decrease in acidic strength.

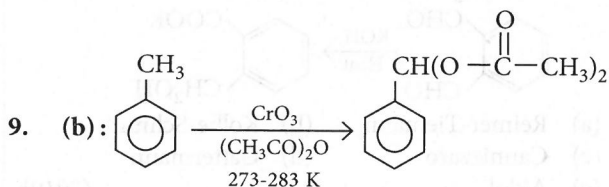
More the number of alkyl group lesser the acidic strength. Hence, the correct order is



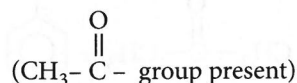
6. (e) :



8. (a)



10. (b): P and R $\longrightarrow$ give Positive iodoform test



R $\longrightarrow$ gives Positive Fehling's test (Aldehyde except benzaldehyde)

Q and R $\longrightarrow$ gives Positive Tollens' test (Aldehyde)

i.e. R is an aliphatic aldehyde with $\text{CH}_3-\text{C}(=\text{O})-$ group, i.e. CH_3CHO (acetaldehyde).

Q is an aldehyde but does not give Fehling's and iodoform test i.e. Q must be $\text{C}_6\text{H}_5\text{CHO}$ (benzaldehyde).

P does not give any test of aldehyde but forms iodoform, so,

it is a methyl ketone i.e. $\text{CH}_3-\text{C}(=\text{O})-\text{CH}_3$ (acetone).

S does not respond to any of the test so, it is a ketone but not a methyl ketone, so, it is a diethyl ketone.

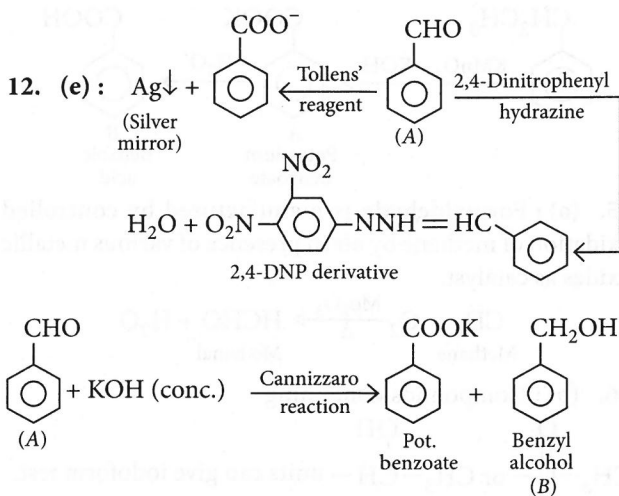
11. (a): The acidic strength of carboxylic acid depends upon the given factors:

(i) Higher the no. of electron withdrawing groups attached adjacent to $-\text{COOH}$ group higher will be the acidic strength.

(ii) Closer the electron withdrawing groups to $-\text{COOH}$ group, higher will be acidic strength of $-\text{COOH}$ group as it stabilises the carboxylate ions more effectively.

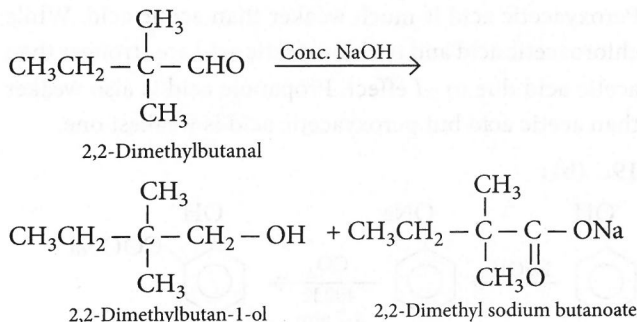
Thus, the correct order of acidic strength will be $\text{ClCH}_2-\text{CH}_2-\text{COOH} < \text{ClCH}_2\text{COOH} < \text{NC}-\text{CH}_2\text{COOH} < \text{CHCl}_2\text{COOH}$.

Note: In the given question, both the options (c) and (e) are same.

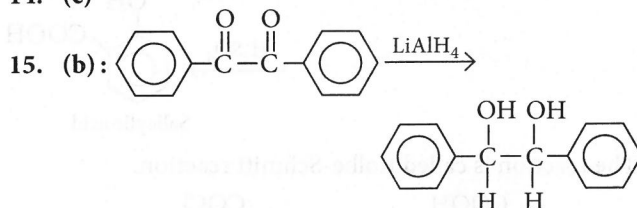


Note: In question, it should be potassium benzoate, instead of sodium benzoate.

13. (c): Aldehydes having no α -hydrogen undergo Cannizzaro reaction. Among the given compounds, 2,2-dimethylbutanal does not have any α -hydrogen. Therefore, it undergoes Cannizzaro reaction.



14. (c)

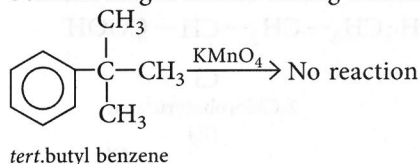


The product has two chiral centres and it contains a centre of symmetry.

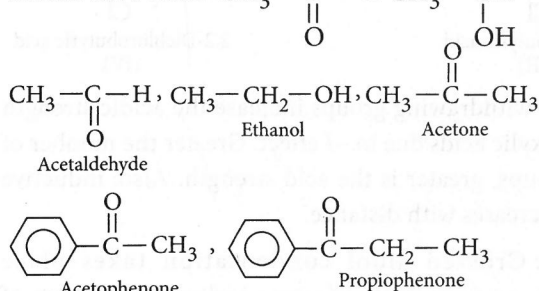
$$\begin{aligned} \text{Total optical isomers} &= 2^{(n-1)} + 2^{(n/2-1)} \\ &= 2^1 + 2^0 = 2 + 1 = 3 \end{aligned}$$

16. (d): With hot and acidic KMnO_4 , all homologues of toluene i.e., benzyl alcohol, n -butyl benzene and styrene are oxidised to $-\text{COOH}$ group irrespective of the length of side chain.

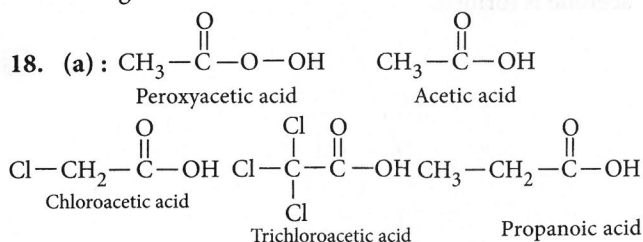
But if side chain has no C—H bond at α -carbon, then benzene ring is broken during oxidation.



17. (e): For a compound to undergo haloform reaction it should have either $\text{CH}_3-\text{C}(=\text{O})-$ or $\text{CH}_3-\text{CH}(\text{OH})-$ group.

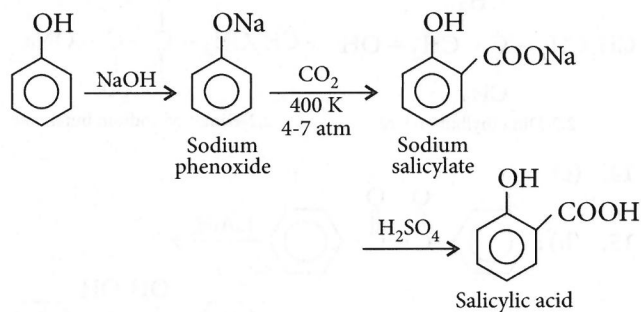


Thus, out of the given examples, only propiophenone will not undergo haloform reaction.

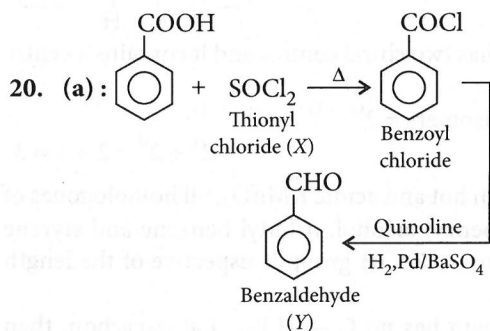


Peroxyacetic acid is much weaker than acetic acid. While chloroacetic acid and trichloroacetic acid are stronger than acetic acid due to $-I$ effect. Propanoic acid is also weaker than acetic acid but peroxyacetic acid is weakest one.

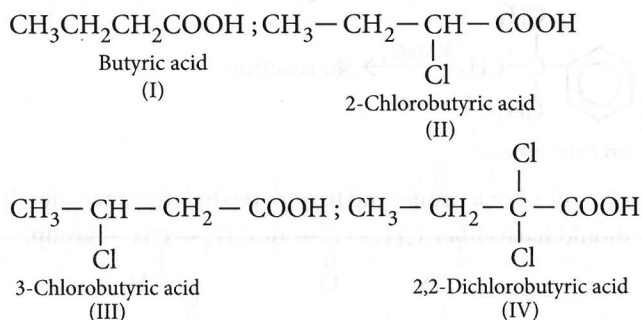
19. (b):



The reaction is called Kolbe-Schmitt reaction.

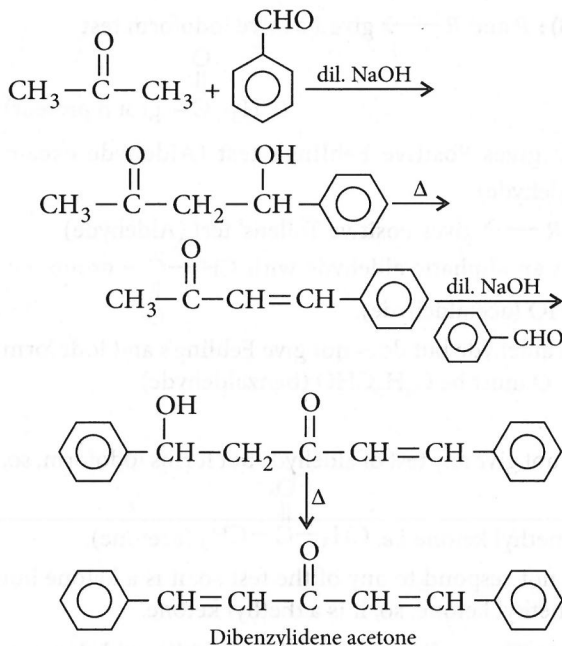


21. (c):



Electron withdrawing groups increase the acidic strength of carboxylic acids due to $-I$ effect. Greater the number of such groups, greater is the acid strength. Also, inductive effect decreases with distance.

22. (c): Crossed aldol condensation takes place between one equivalent of acetone and two equivalents of benzaldehyde in presence of dilute alkali and dibenzylidene acetone is formed.



23. (e): Kolbe's reaction of phenol: It is an electrophilic substitution reaction.

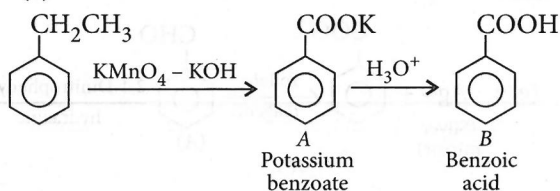
Williamson's synthesis of ethers: It occurs by S_N2 mechanism.

Reimer-Tiemann's reaction of phenol: It is an example of electrophilic substitution reaction involving dichlorocarbene as the electrophile.

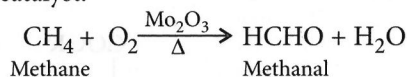
Kolbe's electrolytic synthesis of ethane from sodium acetate: It involves free radical mechanism.

Aldol formation from ethanal: It is nucleophilic addition reaction.

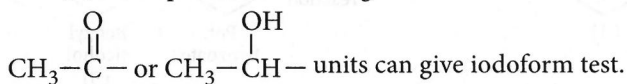
24. (e):



25. (a): Formaldehyde is manufactured by controlled oxidation of methane by air in presence of various metallic oxides as catalyst.



26. (b): Compounds containing



Organic Compounds Containing Nitrogen

- Which of the following amines will not undergo carbylamine reaction?
 (a) *N*-methylethanamine (b) Phenylmethanamine
 (c) Aniline (d) Ethanamine
 (e) Propan-2-amine (2024)
- Chlorophenylmethane is treated with ethanolic NaCN and the product obtained is reduced with H_2 in the presence of finely divided nickel to give
 (a) phenylmethanamine
 (b) 1-phenylethanamine
 (c) 2-phenylethanamine
 (d) 1-methyl-2-phenylethanamine
 (e) phenylmethanamine. (2024)
- A reagent that can be used to reduce benzene diazonium chloride to benzene is
 (a) ethanol (b) methanol
 (c) methanoic acid (d) acetone
 (e) phosphorous acid. (2024)
- The decreasing order of basic strength in aqueous solution of amines is
 (a) Dimethylamine > Methylamine > Trimethylamine > Ammonia
 (b) Methylamine > Dimethylamine > Trimethylamine > Ammonia
 (c) Trimethylamine > Dimethylamine > Methylamine > Ammonia
 (d) Ammonia > Trimethylamine > Dimethylamine > Methylamine
 (e) Ammonia > Dimethylamine > Trimethylamine > Methylamine (2024)
- The decreasing order of basic strength of amines in aqueous medium is
 (a) $CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N > NH_3$
 (b) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$
 (c) $(CH_3)_2NH > (CH_3)_3N > CH_3NH_2 > NH_3$
 (d) $(CH_3)_2NH > NH_3 > (CH_3)_3N > CH_3NH_2$
 (e) $NH_3 > CH_3NH_2 > (CH_3)_3N > (CH_3)_2NH$ (2024)
- When benzene diazonium fluoroborate is heated with aqueous sodium nitrite solution in the presence of copper, the product formed is
 (a) fluorobenzene (b) benzene
 (c) phenol (d) *p*-nitrophenol
 (e) nitrobenzene. (2022)
- Which of the following is used as insect attractant?
 (a) Propan-1-amine
 (b) *N,N*-Dimethylmethanamine
 (c) Propan-2-amine
 (d) *N,N*-dimethylbutan-1-amine
 (e) Ethanamine (2024)
- In which of the following reactions, we will get new C—C bond?
 (a) Cannizzaro reaction and Aldol condensation reaction
 (b) Cannizzaro reaction and Sandmeyer's reaction
 (c) Friedel-Crafts reaction and Gattermann-Koch reaction
 (d) Cannizzaro reaction and Reimer-Tiemann reaction
 (e) Sandmeyer's reaction and Aldol condensation reaction. (2023)
- Match the following columns (P) with (Q) :

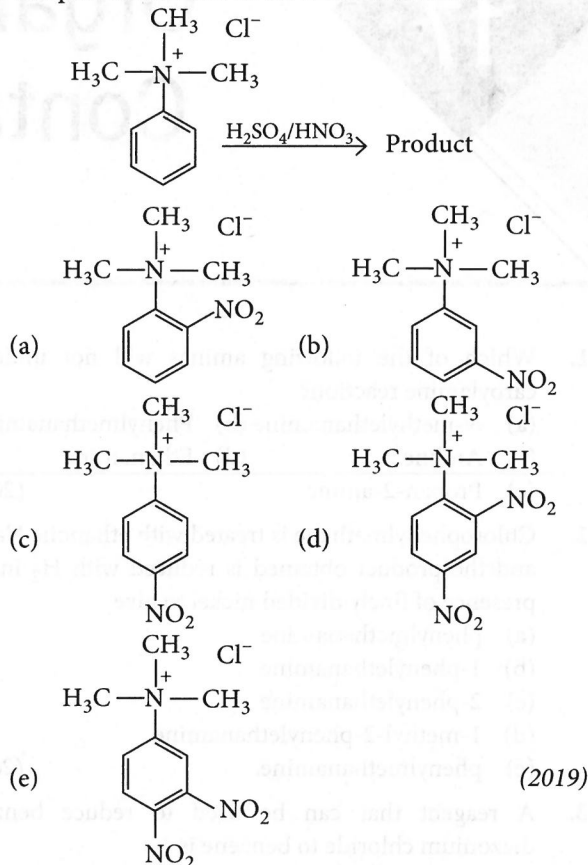
(P)	(Q)
A. Grignard reagent	(i) $AlCl_3$
B. Sandmeyer's reaction	(ii) Sodium metal
C. Cannizzaro reaction	(iii) $Cu(I)$
D. Friedel-Crafts reaction	(iv) CH_3MgBr
E. Wurtz reaction	(v) $NaOH$

 (a) (A)-(iv); (B)-(iii); (C)-(ii); (D)-(i); (E)-(v)
 (b) (A)-(v); (B)-(ii); (C)-(iii); (D)-(iv); (E)-(i)
 (c) (A)-(iv); (B)-(i); (C)-(v); (D)-(iii); (E)-(ii)
 (d) (A)-(ii); (B)-(iii); (C)-(i); (D)-(v); (E)-(iv)
 (e) (A)-(iv); (B)-(iii); (C)-(v); (D)-(i); (E)-(ii) (2023)
- The product formed, when benzene diazonium fluoroborate is heated with aqueous sodium nitrite solution in the presence of copper is
 (a) fluorobenzene (b) benzene
 (c) phenol (d) *p*-nitrophenol
 (e) nitrobenzene. (2022)
- Among methanamine, ethanamine, benzenamine, *N*-methylaniline and *N,N*-dimethylaniline, the

weakest and the strongest base in aqueous phase, respectively are

- benzenamine and methanamine
 - N*-methylaniline and ethanamine
 - N,N*-dimethylaniline and ethanamine
 - benzenamine and ethanamine
 - N*-methylaniline and methanamine. (2022)
12. Which one of the following is not correct with respect to properties of amines?
- pK_b of aniline is more than that of methylamine.
 - Ethylamine is soluble in water whereas aniline is not.
 - Ethanamide on reaction with Br_2 and NaOH gives ethylamine.
 - Ethylamine reacts with nitrous acid to give ethanol.
 - Aniline does not undergo Friedel Crafts reaction. (2021)
13. Which one of the following can be prepared by Gabriel phthalimide synthesis?
- 2-Aminotoluene
 - Aniline
 - 4-Bromoaniline
 - Allylamine
 - N*-Methylethanamine (2020)
14. The reagent that is used to distinguish between a secondary amine and a tertiary amine is
- p*-toluenesulphonyl chloride
 - dil. HCl
 - dil. NaOH
 - CHCl_3 and alc. KOH
 - bromine water. (2020)
15. Cyclohexylamine and aniline can be distinguished by
- Hinsberg's test
 - Carbylamine test
 - Bromine test
 - Beilstein's test
 - Lassaigne's test. (2019)
16. In the Hofmann rearrangement of primary amides having optically active group with *S*-configuration, the product amine has
- R*-configuration
 - S*-configuration
 - racemic mixture
 - meso*-form
 - achiral nature. (2019)
17. Benzonitrile can be prepared from benzaldehyde on treatment with
- NH_3
 - NH_3 followed by hydrogenation with Ni
 - NH_2OH
 - NH_2OH followed by dehydration with acetic anhydride
 - hydrogen cyanide. (2019)

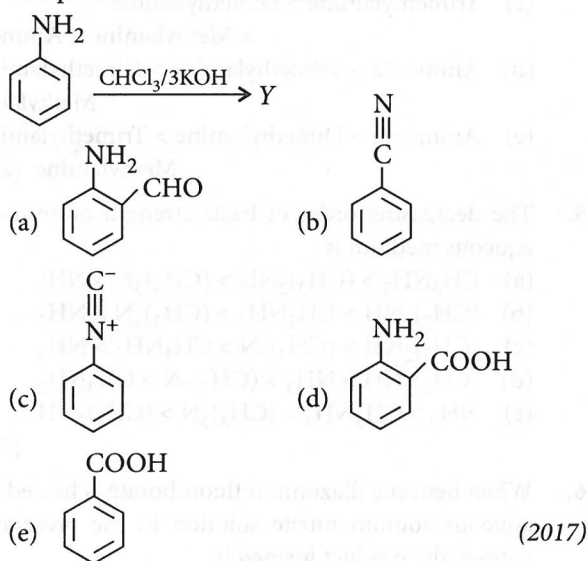
18. The product formed in the below reaction is



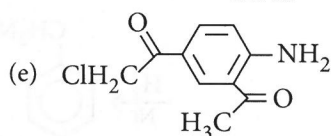
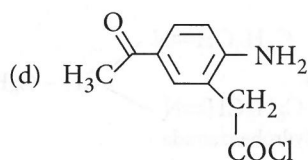
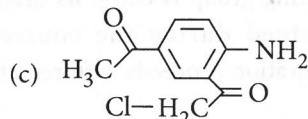
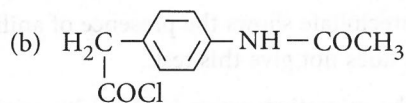
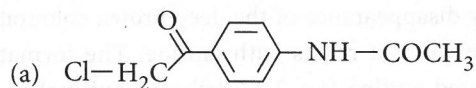
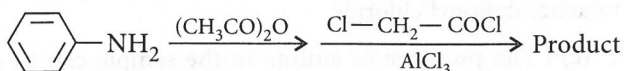
19. The nitrosation of *N,N*-dimethylaniline takes place through the attack of electrophile

- nitronium ion
 - protonated nitrous acid
 - nitrous acid
 - nitrite ion
 - nitrosonium ion. (2018)
20. The strongest base among the following is
- amide ion
 - hydroxide ion
 - trimethylamine
 - ammonia
 - aniline. (2017)

21. The product *Y* for the below reaction is



22. The product formed in the following reaction is



(2017)

23. Which one of the following can be prepared by Gabriel phthalimide synthesis?

- (a) Aniline (b) *o*-Toluidine
(c) Benzylamine (d) *N*-Methylethanamine
(e) 4-Bromoaniline (2016)

24. 4-Nitrotoluene is treated with bromine to get compound 'P'. 'P' is reduced with Sn and HCl to get compound 'Q'. 'Q' is diazotised and the product is treated with phosphinic acid to get compound 'R'. 'R' is oxidized with alkaline KMnO_4 to get compound 'S'. Compound 'S' is

- (a) 2-bromo-4-hydroxybenzoic acid
(b) benzoic acid
(c) 4-bromobenzoic acid
(d) 3-bromobenzoic acid
(e) 2-bromobenzoic acid. (2016)

25. Which one of the following is used as a test for aliphatic primary amines?

- (a) Tollen's test (b) Fehling's test
(c) Isocyanide test (d) Azo dye test
(e) Phthalain fusion test (2015)

26. When methanamine is treated with benzoyl chloride, the major product is

- (a) *N*-phenylethanamide (b) *N*-methylbenzamide
(c) benzanilide (d) acetophenone
(e) *N*-ethylethanamide. (2015)

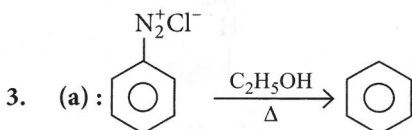
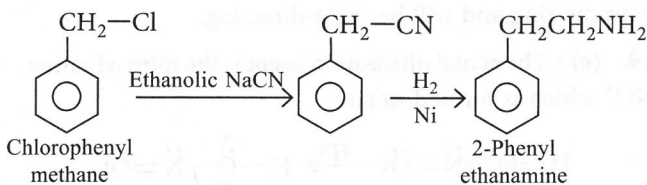
Answer Keys

1. (a) 2. (c) 3. (a) 4. (a) 5. (b) 6. (d) 7. (b) 8. (c) 9. (e) 10. (e)
11. (d) 12. (c) 13. (d) 14. (a) 15. (c) 16. (b) 17. (d) 18. (b) 19. (e) 20. (a)
21. (c) 22. (a) 23. (c) 24. (e) 25. (c) 26. (b)

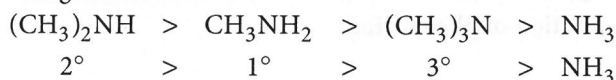
Hints & Explanations

1. (a): Only aliphatic and aromatic primary amines undergo carbylamine reaction.

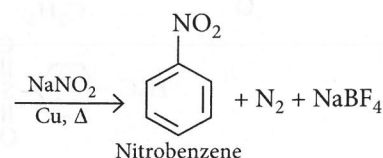
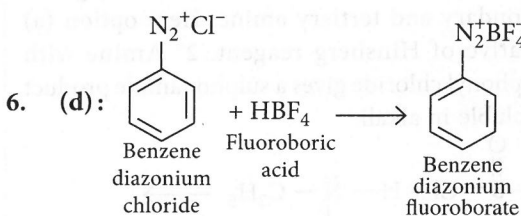
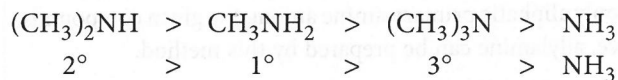
2. (c):



4. (a): Basic strength of amines in aqueous solution is affected by solvation effect, steric hindrance and inductive effect. Resultant of all these effects give the order of basic strength as follows:



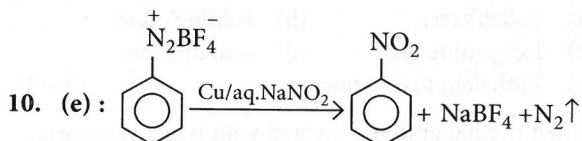
5. (b): Basic strength in aqueous medium depends on hydrogen bonding, steric hindrance and inductive effect. Resultant of all the effect gives following order of basic strength:



7. (b): *N,N*-Dimethyl methanamine is used as an insect attractant.

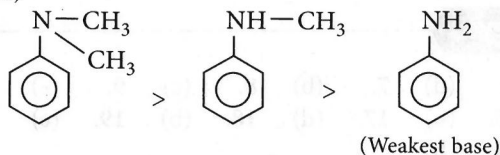
8. (c): In Friedel-Crafts reaction, introduction of $-R$ or $R-\overset{\text{O}}{\parallel}{C}-$ groups occur. So, new C—C bond is formed. Also, in case of Gattermann-Koch reaction introduction of $-\text{CHO}$ group occurs, which also leads to formation of C—C bond. In aldol condensation and in Reimer-Tiemann reactions, new C—C bond will be formed. But in Sandmeyer's and in Cannizzaro reaction, no new C—C bond will be formed.

9. (e): (A) Grignard reagent $\longrightarrow$ (iv) CH_3MgBr
 (B) Sandmeyer's reaction $\longrightarrow$ (iii) Cu(I)
 (C) Cannizzaro reaction $\longrightarrow$ (v) NaOH
 (D) Friedel-Crafts reaction $\longrightarrow$ (i) AlCl_3
 (E) Wurtz reaction $\longrightarrow$ (ii) Sodium metal

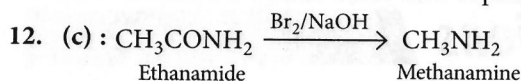


11. (d): Group having +I effect increases basicity of amines while $-I$ effect decreases it.

So order of basicity is
 $\text{CH}_3\text{CH}_2\text{NH}_2 > \text{CH}_3\text{NH}_2 >$
 (Strongest base)



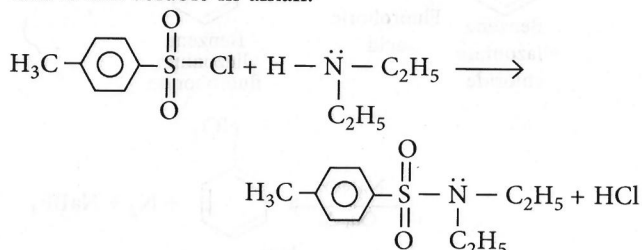
Aromatic amines are weaker bases than aliphatic amines.



Ethanamide on reaction with Br_2 and NaOH gives methylamine.

13. (d): Gabriel phthalimide synthesis is used for the preparation of aliphatic primary amines. Since, allylamine is the only aliphatic primary amine among the given compounds hence, allylamine can be prepared by this method.

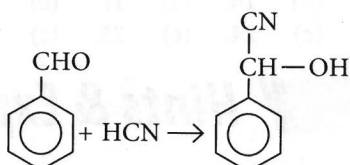
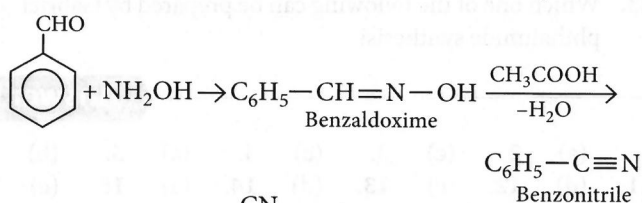
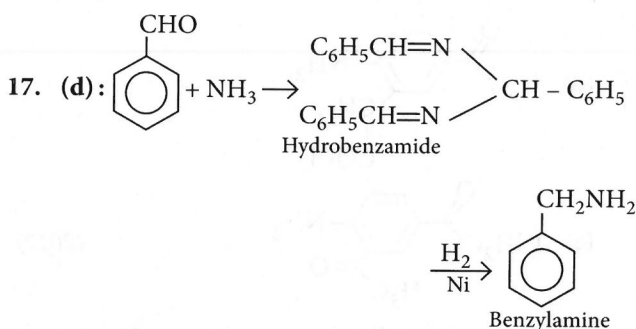
14. (a): Hinsberg's reagent is used to distinguish between secondary and tertiary amine. Here option (a) is the derivative of Hinsberg reagent. 2° Amine with *p*-toluenesulphonyl chloride gives a sulphonamide product that is not soluble in alkali.



No such reaction occurs between tertiary amine and *p*-toluenesulphonyl chloride.

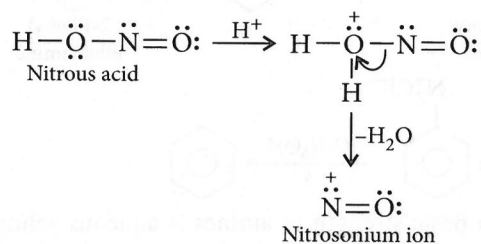
15. (c): The presence of aniline in the sample can be detected by disappearance of the deep brown colouration of bromine when it reacts with aniline. The formation of brominated aniline (i.e., 2,4,6-tribromoaniline) in the form of a white precipitate shows the presence of aniline. Cyclohexylamine does not give this test.

16. (b): When the migrating group is chiral its original stereochemistry is retained during the course of rearrangement i.e., the migration proceeds with retention of configuration.



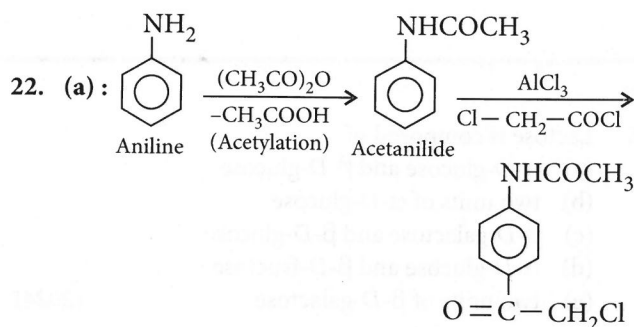
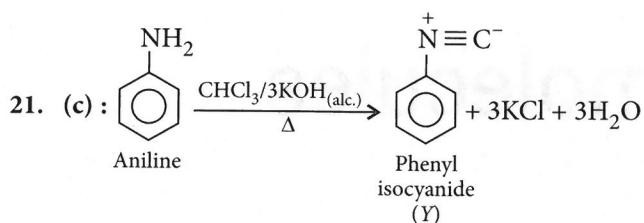
18. (b): As nitrogen is positively charged, thus it will act as electron withdrawing group so it will deactivate the benzene ring and will be *meta*-directing.

19. (e): The actual nitrosation agent is the nitrosyl cation, NO^+ which is formed in situ.



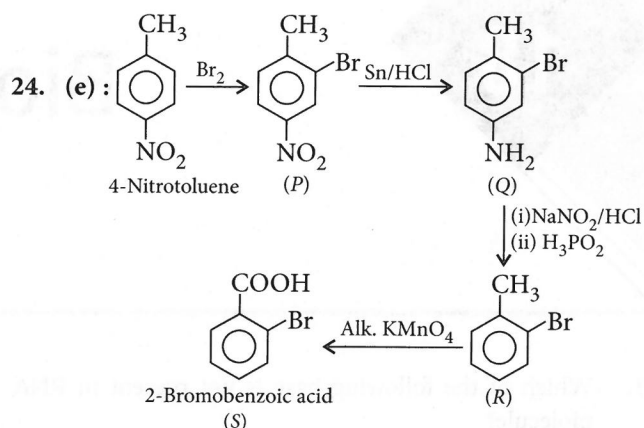
Aromatic tertiary amine i.e., *N,N*-dimethyl aniline, undergo electrophilic substitution with nitrosonium ion at *p*-position of phenyl ring.

20. (a)

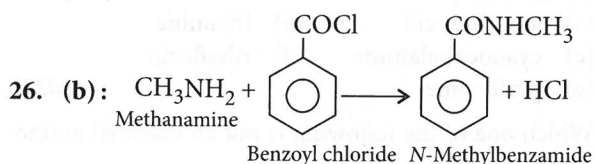
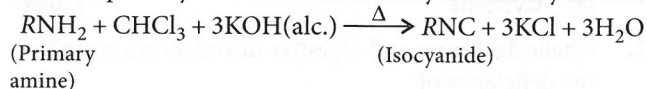


23. (c): Only primary aliphatic amines can be prepared by Gabriel phthalimide synthesis.

Hence, benzylamine can be prepared from Gabriel phthalimide synthesis.



25. (c): Isocyanide test is used to distinguish aliphatic and aromatic primary amines from secondary and tertiary amines.



Biomolecules

- Which of the following base is not present in RNA molecule?
(a) Adenine (b) Guanine
(c) Thymine (d) Uracil
(e) Cytosine (2024)
- Cheilosis disease and digestive disorders are caused by the deficiency of
(a) ascorbic acid (b) thiamine
(c) cyanocobalamine (d) riboflavin
(e) pyridoxine (2024)
- Which one of the following is not an essential amino acid?
(a) Lysine (b) Tyrosine
(c) Threonine (d) Tryptophan
(e) Methionine (2024)
- The melting point of β -form of crystalline glucose is
(a) 473 K (b) 303 K
(c) 423 K (d) 371 K
(e) 503 K (2024)
- Which of the following vitamin deficiency causes increased fragility of RBCs and muscular weakness?
(a) Vitamin A
(b) Vitamin B₁₂
(c) Riboflavin
(d) Vitamin D
(e) Vitamin E (2024)
- The percentage amylose in starch is about
(a) 40-50% (b) 80-85%
(c) 60-80% (d) 50-60%
(e) 15-20% (2024)
- Which of the following statement is correct?
(a) Sucrose is laevorotatory.
(b) Fructose is a disaccharide.
(c) Sucrose on hydrolysis gives $D(+)$ -glucose only.
(d) Sucrose is made up of a glycosidic linkage between C1 of α -D-glucose and C2 of β -D-Fructose.
(e) Sucrose is a reducing sugar. (2024)
- A fibrous protein present in muscles is
(a) keratin (b) albumin
(c) riboflavin (d) insulin
(e) myosin. (2024)
- Lactose is composed of
(a) α -D-glucose and β -D-glucose
(b) two units of α -D-glucose
(c) β -D-galactose and β -D-glucose
(d) α -D-glucose and β -D-fructose
(e) two units of β -D-galactose (2024)
- In oligosaccharides, how many monosaccharides will be present?
(a) 1 to 5 (b) 2 to 10 (c) 4 to 5 (d) 1 to 15
(e) 3 to 5 (2023)
- In DNA molecule, the sugar part is _____ and in RNA molecule, the sugar part is _____.
(a) β -D-2-ribose and α -L-ribose
(b) β -D-2-deoxyribose and α -L-ribose
(c) β -D-3-deoxyribose and α -D-ribose
(d) α -D-2-deoxyribose and β -D-ribose
(e) β -D-2-deoxyribose and β -D-ribose (2023)
- Which statement is correct in the following ?
(a) Amylose is a polymer of α -D-glucose.
(b) Amylose is a polymer of β -D-glucose.
(c) Cellulose is a polymer of α -D-glucose.
(d) Cellulose is a polymer of β -D-galactose.
(e) Amylose is a polymer of α -D-galactose. (2023)
- Which one of the following is a polysaccharide?
(a) Glycogen (b) Lactose
(c) Maltose (d) Sucrose
(e) Glucose (2022)
- Which one of the following statements is true with regard to glucose?
(a) It gives Schiff's test.
(b) It forms addition product with NaHSO₃.
(c) Its pentaacetate does not react with NH₂OH.
(d) It does not undergo mutarotation.
(e) β - form of glucose is obtained by crystallisation from conc. solution of glucose at 303 K. (2021)
- An invert sugar is
(a) isorotatory
(b) laevorotatory
(c) dextrorotatory
(d) optically inactive
(e) mutarotatory. (2019)

16. The nitrogenous base present only in RNA is
 (a) guanine (b) adenine
 (c) cytosine (d) uracil
 (e) thymine. (2018)
17. Protein is a polymer made of
 (a) carbohydrates
 (b) amino acids
 (c) nucleic acids
 (d) carboxylic acids
 (e) polycyclic aromatic. (2017)
18. The letter 'D' in D-carbohydrates represents
 (a) dextrorotation (b) direct synthesis
 (c) configuration (d) mutarotation
 (e) optical activity. (2017)
19. Enzymatic reactions are given in Column-I and enzymes in Column-II
- | Column-I | Column-II |
|---|----------------|
| (A) Maltose → Glucose | (i) Zymase |
| (B) Sucrose → Glucose + Fructose | (ii) Pepsin |
| (C) Glucose → Ethyl alcohol + CO ₂ | (iii) Maltase |
| (D) Starch → Maltose | (iv) Invertase |
| (E) Proteins → Amino acids | (v) Diastase |
- Choose the correct matching of enzymatic reaction and enzyme that catalyses the correct reaction from the codes given below :
- (a) (A) - (ii), (B) - (iv), (C) - (v), (D) - (iii), (E) - (i)
 (b) (A) - (iii), (B) - (iv), (C) - (i), (D) - (v), (E) - (ii)
 (c) (A) - (v), (B) - (iv), (C) - (ii), (D) - (i), (E) - (iii)
 (d) (A) - (v), (B) - (iii), (C) - (iv), (D) - (ii), (E) - (i)
 (e) (A) - (ii), (B) - (iii), (C) - (i), (D) - (v), (E) - (iv) (2016)
20. In double strand helix structure of DNA, heterocyclic base cytosine forms hydrogen bond with
 (a) adenine (b) guanine
 (c) purine (d) thymine
 (e) uracil. (2016)
21. The amino acid containing mercaptan unit is
 (a) leucine (b) glutamine
 (c) cysteine (d) lysine
 (e) isoleucine. (2016)
22. Which one of the following is a non-reducing sugar?
 (a) Maltose (b) Lactose
 (c) Sucrose (d) Glucose
 (e) Fructose (2016)
23. The enzyme that converts glucose into ethyl alcohol and carbon dioxide is
 (a) invertase
 (b) maltase
 (c) urease
 (d) diastase
 (e) zymase. (2015)
24. In DNA, the consecutive deoxynucleotides are connected by
 (a) phosphodiester linkage
 (b) phosphomonoester linkage
 (c) phosphotriester linkage
 (d) amide linkage
 (e) imide linkage. (2015)

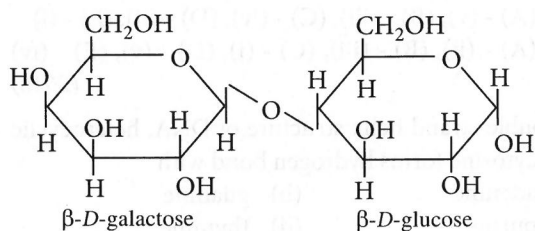
Answer Keys

1. (c) 2. (d) 3. (b) 4. (c) 5. (e) 6. (e) 7. (d) 8. (e) 9. (c) 10. (b)
 11. (e) 12. (a) 13. (a) 14. (c) 15. (b) 16. (d) 17. (b) 18. (c) 19. (b) 20. (b)
 21. (c) 22. (c) 23. (e) 24. (a)

Hints & Explanations

1. (c) : DNA contains four bases viz. adenine (A), guanine (G), cytosine (C) and thymine (T). RNA also contains four bases, the first three bases are same as in DNA but the fourth one is uracil (U), instead of thymine (T).
2. (d) : Cheilosis (the fissuring at corners of mouth and lips) is caused by the deficiency of vitamin B₂ (Riboflavin).
3. (b) : Tyrosine is not an essential amino acid.
4. (c) : Melting point of β-form of crystalline glucose is 423 K.
5. (e) : Deficiency of Vitamin E causes increased fragility of RBCs and muscular weakness.

6. (e) : Starch exist as Amylose = 15-20% and Amylopectin = 85-80%
7. (d) : Sucrose is non-reducing sugar, as both mono-saccharide units are held together by glycosidic linkage between C-1 of α-glucose and C-2 of β-fructose, reducing groups of both units are involved in bonding and not free.
8. (e) : A fibrous protein present in muscles is myosin.
9. (c) : Lactose is disaccharide sugar, that is composed of β-D-glucose and β-D-galactose, linked with glycosidic linkage



10. (b): 2 – 10 units of monosaccharides are present in oligosaccharides.

11. (e)

12. (a): Amylose is a polymer of α -D-glucose. Cellulose is a polymer of β -D-glucose.

13. (a): Glycogen is a polysaccharide of glucose while lactose, maltose and sucrose are disaccharides and glucose is a monosaccharide.

14. (c): As glucose does not contain free aldehyde group in cyclic form so, it does not give Schiff's test and does not form addition product with NaHSO_3 . Glucose undergoes mutarotation.

When glucose is crystallized from a conc. solution at 303 K and 371 K, it gives α - and β - form of glucose respectively.

15. (b)

16. (d)

17. (b): Proteins are the condensation polymers of α -amino acids.

18. (c): The letter 'D' in D-carbohydrates represents configuration. A monosaccharide is assigned D-configuration if the —OH group at the last chiral carbon lies towards right hand side.

19. (b): Maltose $\xrightarrow{\text{Maltase}}$ Glucose

Sucrose $\xrightarrow{\text{Invertase}}$ Glucose + Fructose

Glucose $\xrightarrow{\text{Zymase}}$ Ethyl alcohol + CO_2

Starch $\xrightarrow{\text{Diastase}}$ Maltose

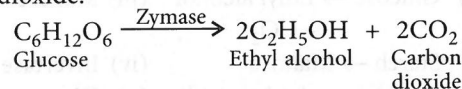
Proteins $\xrightarrow{\text{Pepsin}}$ Amino acids

20. (b): Cytosine forms three hydrogen bonds with guanine.

21. (c): Side chain in cysteine is $-\text{CH}_2\text{SH}$.

22. (c): Sucrose is a disaccharide in which the two monosaccharide units are linked through their reducing centres.

23. (e): Zymase converts glucose into ethyl alcohol and carbon dioxide.



24. (a): In DNA, deoxynucleotides are connected together by phosphodiester linkage.

